SCIENTIFIC AMERICAN SUPPLEMENT, No. 1901

Entered at the Post Office of New York, N. Y., as Second Class Matter.

Copyright, 1910, by Munn & Co., Inc.

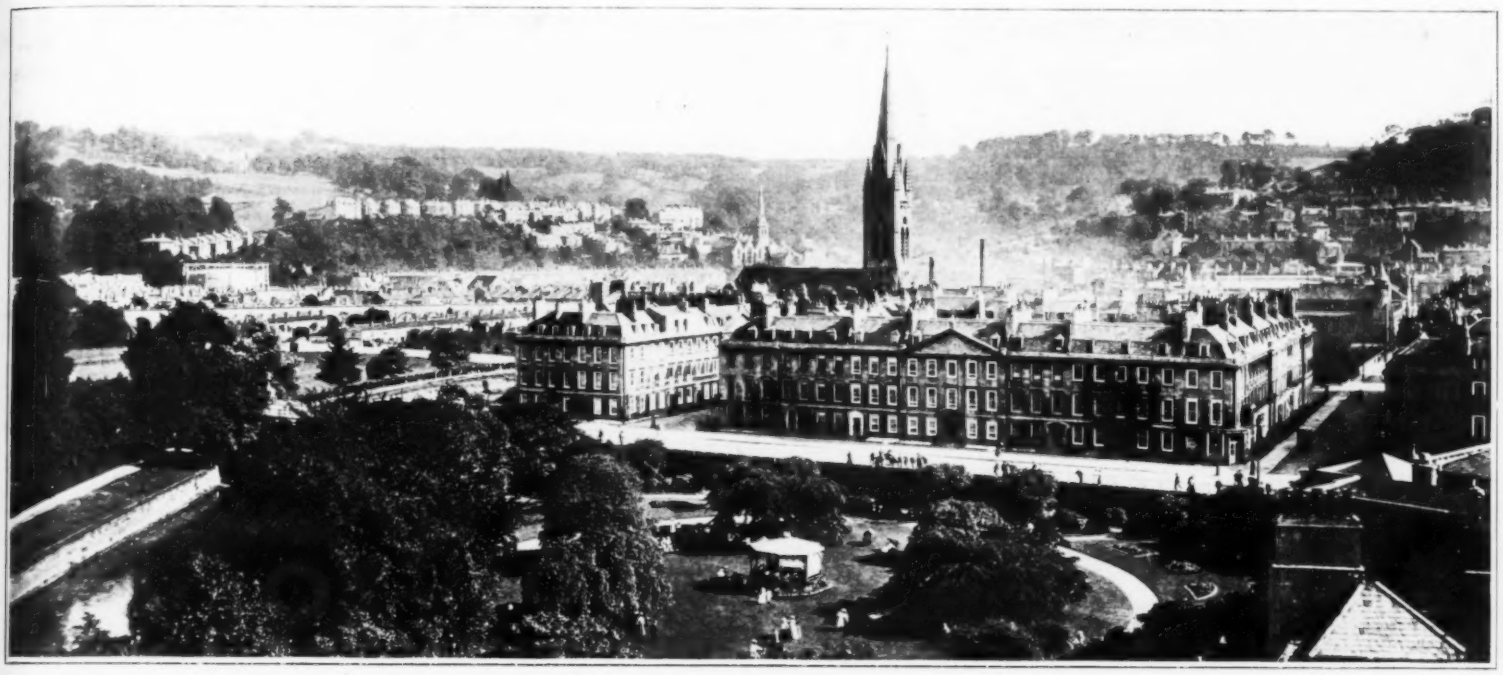
Frederick Converse Beach, Sec'y and Treas., 361 Broadway, New York.

Charles Allen Munn, President, 361 Broadway, New York.
Published weekly by Munn & Co., Inc., at 361 Broadway, New York.

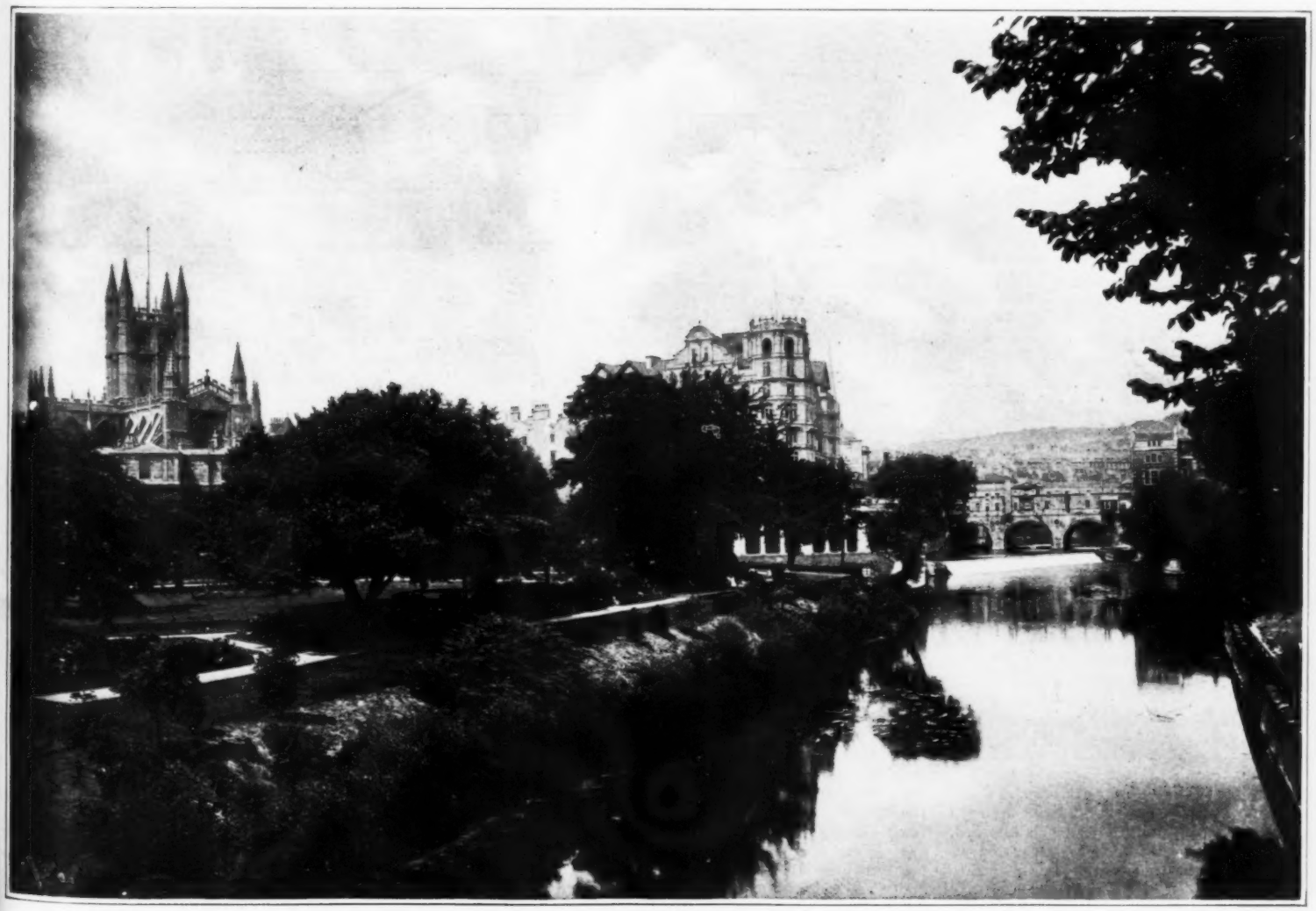
Scientific American, established 1847.
Scientific American Supplement, Vol. LXXIII., No. 1901.

NEW YORK, JUNE 8, 1912.

Scientific American Supplement $5 a year.
Scientific American and Supplement, $7 a year.



The Institution Gardens and Hot Spring



The Gardens and the River Avon.

RADIUM IN THE WATERS OF BATH, THE HISTORIC ENGLISH CITY.—[See page 360.]

Iron and Steel Metallurgy in Brief*

A Summary of the Processes Which Result in Various Descriptions of Product from Iron Ore to Finished Forms

The following summary statement, which indicates the line of processes involved in the manufacture of iron and steel, beginning with iron ore and ending with the various forms of finished products, has been compiled by Eliot A. Kebler, 1844 Oliver Bldg., Pittsburgh, resident agent of M. A. Hanna & Co. With it are given chemical analyses of iron ore, pig iron, semi-finished steel and finished materials, including the products of iron and steel foundries:

From Ore to Finished Product

Iron Ore	Contains Iron and Oxygen and impurities	
Iron Ore	Smelted in *Blast Furnace*, removing Oxygen and part of impurities and adding Carbon, makes	**Pig Iron**
Foundry Pig Iron	Melted in *Cupola* and cast makes	**Iron Castings**
Iron Castings	Made from Malleable Pig Iron and heated in Scale make	**Malleable Castings**
Grey Forge Pig Iron	Melted in a *Puddling Furnace*, then balled, squeezed and rolled, makes	**Muck Bar**
Muck Bar	or Wrought Scrap cut into short lengths, piled, heated and rolled, makes	**Wrought Iron**
Muck Bar	Treated as above and rolled into strips, makes	**Skelp Iron**
Skelp Iron	Bent into the shape of tubes and welded, makes	**Iron Pipe**
Muck Bar	Or *Steel* melted in a *Crucible* with Charcoal, makes *Carbon Steel*, *Tool Steel* or	**Crucible Steel**
Muck Bar	Or *Steel* treated as above, with Tungsten added to raise the temperature at which it softens, Chromium to give toughness, and Vanadium, Titanium, Aluminum or other metals to improve the quality, heated to a high, then to a lower heat makes	**High Speed Steel**
Bessemer Pig Iron	Direct from *Blast Furnace* or melted in *Cupola*, poured into *Converter*, with air blown through it to burn out the impurities makes	**Bessemer Steel**
Pig Iron	Molten, or in pig, with or without Scrap, when purified in *Open Hearth Furnace* makes	**Open Hearth Steel**
Low Phos. Pig Iron	Treated as above in an acid (Silica or Sand) lined furnace makes	**Acid O. H. Steel**
Basic Pig Iron	Treated as above in a basic (Dolomite) lined furnace to remove Phosphorus makes	**Basic O. H. Steel**
Basic O. H. Steel	With only about 1-10 of 1% impurities is called by various trade names, such as *Tuscan Metal*, *Genuine Open Hearth Iron* and *American Ingot Iron*.	
Vanadium Steel	Or *Manganese* (over 7 %), *Titanium* or *Nickel Steel* is made by the addition of these metals, all being called,	**Alloy Steels**
Steel	Purified in an *Electric Furnace*, makes	**High Grade Steel**
Steel	Is cast into ingot molds usually about 19 in. sq. and about 6 ft. long, making	**Ingots**
Ingots	Are rolled into	**Blooms or Billets**
Blooms	Are rolled into	**Rails**
Blooms	Are rolled into	**Structural Shapes**
Ingots	Are rolled into	**Slabs**
Slabs	Are rolled into	**Plates**
Ingots	Are rolled into	**Sheet Bars**
Sheet Bars	Are rolled into	**Sheets**
Sheets	Are cold rolled and stamped into	**Forms**
Sheet Bars	Are rolled into	**Black Sheets**
Black Sheets	Cleaned and coated with *Spelter* (Zinc) make	**Galvanized Sheets**
Black Sheets	Cleaned, cold rolled and coated with *Tin* make	**Tin Plate**
Black Sheets	Cleaned, cold rolled and coated with *Lead* and *Tin* make	**Terne Plate**
Ingots	Are rolled into	**Billets**
Billets	Are rolled into	**Bars and Small Shapes**
Billets	Are rolled into	**Steel Skelp**
Steel Skelp	Bent into the shape of tubes and welded makes	**Steel Pipe**
Billets	Are pierced, rolled and drawn through dies, making	**Seamless Tubes**
Billets	Are rolled into	**Rods**
Rods	Are drawn through dies into	**Wire**
Wire	Is made into	**Nails and Fencing**
Rods	Are headed into	**Rivets and Bolts**
Rods	Are welded into	**Chain**

* Reproduced from *The Iron Age*.

Typical Analyses and Specifications of the Above

LAKE SUPERIOR IRON ORES (Natural Condition)

Brand	Loss on Ignition	Moisture	Iron	Sil.	Sul.	Phos.	Manganese
American (Marquette)	1.08	2.05	56.42	12.09	0.011	0.039	0.04
Montrose (Gogebic)	2.79	10.92	54.29	5.88	0.029	0.069	0.37
Dover (Mesaba)	4.26	13.37	51.89	5.03	0.009	0.068	0.54
Republic Basic Lump (Used for Open Hearth fix)	None	0.82	65.86	2.34	0.012	0.093	0.06
Beaver (Puddling Furnace fix)	10.71	4.12	56.27	2.69	0.028	0.072	0.38

PIG IRON

	Sil.	Sul.	Phos.	Mang.
High Phosphorus	1.75 to 2.50	0.05 & under	Over 1.00	0.35 to 0.70
No. 2 Foundry*	1.75 to 2.25	0.05 & under	0.40 to 0.60	0.50 to 0.80
Grey Forge*	0.75 & over	Over 0.05	0.40 to 0.60	0.50 to 0.80
Strong Foundry and Car Wheel	0.75 to 1.50	0.05 & under	0.30 & under	.....
Basic (Chill cast)	Not over 1.00	0.05 & under	.....	.....
Malleable	As desired	0.05 & under	0.20 & under	Not over 0.80
Bessemer	1.00 to 2.00	0.05 & under	0.10 & under	.....
Low Phosphorus	1.00 to 2.00	0.035&under	0.035&under	.....

*Mahoning and Shenango Valley.

IRON CASTINGS

	Total Car.	Sil.	Sul.	Phos.	Mang.
Light	3.40	2.75	0.075	0.75	0.40
Medium	3.50	1.75	0.080	0.55	0.60
Semi-steel	3.30	1.30	0.075	0.40	0.45
Malleable	2.50	0.75	0.070	0.19	0.25

WROUGHT IRON

	Total Car.	Sil.	Sul.	Phos.	Mang
Muck Bar	0.10	0.108	0.052	0.193	Not over 0.10
Skelp	0.05	0.040	0.050	0.10	Not over 0.10

STEEL BILLETS AND SHEET BARS

	Car.	Sul.	Phos	Mang.
Bessemer	0.08 to 0.12	0.08 or less	0.09 to 0.12	0.35 to 0.50
Acid O. H.	0.08 to 0.12	0.06 or less	0.08 or less	0.35 to 0.50
Basic O. H. (Soft)	0.08 to 0.12	0.05 or less	0.05 or less	0.30 to 0.45
Basic O. H. (Phos. added)	0.08 to 0.12	0.05 or less	0.08	0.40 to 0.50
Am. Ingot Iron	0.02	0.021	0.005	Trace

RAILS
(Chemical Specification, Asso. of Amn. Steel Manufacturers)

	Car.	Sil.	Phos.	Mang.
Bessemer	0.35 to 0.55	Not over 0.20	Not over 0.10	0.70 to 1.14
Open Hearth	0.46 to 0.75	Not over 0.20	Not over 0.04	0.60 to 0.90

STEEL CASTINGS
(Extract from Specifications, Amer. Society for Testing Materials)

	Minimum Physical Requirements				Maximum		
	Tensile strength lb. per sq. in.	*Yield point lb. per sq. in.	Per cent. elong. in 2 in.	Per cent. red. in area	Car.	Sul.	Phos
Ordinary Cstgs.	None Required				0.40	.....	0.08
Tested Cstgs, Hard	85,000	38,250	15	20	.....	0.05	0.05
Tested Cstgs, Medium	70,000	31,500	18	25	.....	0.05	0.05
Tested Cstgs, Soft	60,000	27,000	22	30	.....	0.05	0.05

BOILER PLATE AND RIVET STEEL

	Flange Steel	Fire Box Steel	Extra Soft Steel
Phos. not to exceed	Acid 0.06% Basic 0.04%	Acid 0.04% Basic 0.03%	0.04%
Sul. not to exceed	0.05%	0.04%	0.04%
Manganese	0.30 to 0.60%	0.30 to 0.50%	0.30 to 0.50%
Ult. T. S. lb. per sq. in.	55,000–65,000	52,000–62,000	45,000–55,000
Yield point, lb. sq. in. not under	½ Ult. T. S.	½ Ult. T. S.	½ Ult. T. S.
Elong. % in 8 in. not under	1,500,000	1,500,000	1,500,000
Cold bend	Ult. T. S.	Ult. T. S.	Ult. T. S. (but need not be over 30%)
Quench bend	180° flat	180° flat	180° flat

STRUCTURAL STEEL FOR BUILDINGS

	Struc. Steel	Rivet Steel O. H.
Phosphorus, maximum, Bessemer	0.10 per cent.	.....
Phosphorus, maximum, Open Hearth	0.06 per cent.	0.06 per cent.
Ultimate tensile strength, pounds per square inch	55,000–65,000	48,000–58,000
Yield point	½ Ult. tens. str.	½ Ult. tens. str.
Elongation, minimum, per cent. in 8 inches	1,400,000	1,400,000
Character of fracture	Ult. tens. str. Silky	Ult. tens. str. Silky
Cold bend without fracture	180° to dia. of 1 thickness	180° flat

TOOL STEEL

	Tungsten	Chromium	Car.	Sul.	Phos.	Sil.	Vanadium
Carbon Steel	.....	.....	1.10	0.03	0.015	0.20	.....
High Speed Steel	18.00	3.50	0.55	0.012 or less	Trace	Trace	1.00

International Trade-Mark Law*

By DR. MARTIN WASSERMANN.

IT is unnecessary to point out to readers of this journal the exceedingly important rôle which trade-marks play in commerce. Their function is to bear testimony for the firm of manufacturers not only at home but abroad, and to guarantee the genuineness of the merchandise. In this way the trade-mark forms one of the most effective weapons at the disposal of the manufacturer and merchant in the warfare of trade. A well established trade-mark represents a valuable asset, but the greater its value the more is it exposed to attacks on the part of unscrupulous imitators.

In all civilized countries the need of an effective legal protection against imitation or other infringement is felt. It is true that systems of trade-mark protection differ considerably in different countries. In particular, two groups can be distinguished, according to the conditions to which legal protection is attached. The first system grants protection to the person who was the first to use the trade-mark. In this case the use itself of the mark creates a right which can, perhaps, be compared with an inventor's or originator's right. This right comes into existence in the person who invents the mark, or who lays hold of the hitherto unclaimed mark, to introduce it as a designation of his wares into the trade. His depositing of the mark in the Government archives in this case is of value merely as a means of proving the right which has already become established. This system is in vogue especially in France and those countries which have followed the example of France. Diametrically opposed to this principle is that followed by the German trade-mark law, which lays no value whatever upon the mere use of the mark, but grants legal protection only to such persons as register the mark in the Imperial Patent Office. Both systems have unquestioned advantages and disadvantages. The German has the undeniable advantage of security; the disadvantage of undue formalism. The French system has the advantage of cheapness; the disadvantage of difficulty in establishing proofs. The laws of the remaining countries follow more or less closely either one or the other system and sometimes show intermediate stages; in brief, the outlook over the whole field is somewhat varied. This variety has great disadvantages for such persons as are seeking to place their wares upon the world's entire market. The immense expansion which commerce and industry in Germany have undergone within the last few decades, diffusing German products over all countries of the world, has the result that the Germans feel this want most severely, and it is therefore only natural that in recent times Germany, in particular, has repeatedly raised the cry for improvement in this respect.

A number of men experienced in the field of trade-mark law, have recently combined and formed a "Society for Trade-Mark Law" in order to lead these efforts toward some concrete result. Quite generally it is the consensus of opinion that the realization of the idea will require serious work, extending over many years. It is proposed, in the first place, to make a close study of the trade-mark laws of all countries and litigation relating thereto, keeping in close touch with the corresponding circles of other countries, and to weigh against one another the advantages and disadvantages of the several systems, in order finally to pick out the best from all of them.

Some, reading these lines, will perhaps shake their heads at what appear to be Utopian plans. It may perhaps seem somewhat strange that in these days of hot conflict, serious-minded men should come together in order to produce a work which represents nothing less than the possible combination of all States of the earth. Nevertheless it must and will be brought about—the tearing down of the barriers dating from the middle ages, which still obtain in this field and which separate the majority of States from one another, for they hinder trade and have long lost the right to existence in our day of world-wide commerce.

* Translated from *Zeitschrift fur angewandte Chemie*.

The Denier System of Silk Measure

Its Nature and Origin

By James Chittick

To explain the origin of this system of counts, it is necessary to hark back to the weights and measures used by the people of France in the times preceding the French Revolution.

It is a singular and significant illustration of the difficulty of changing the weights and measures which a nation has been accustomed to use, and of the tenacity with which people will persist in using their old standards, that, after the lapse of about a century and a quarter, and after many vigorous and persistent efforts, backed by severe laws on the part of succeeding French governments, to compel the exclusive use of the metric system, that it has been found impossible to get those engaged in the silk industry to consent to number their yarns by the standard metric method of so many meters per gramme.

After repeated conferences, and congresses, held to consider this subject for the purpose of trying to induce the silk men to depart from their ancient standards, the best that could be accomplished has been to secure their acquiescence in some slight modifications of the lengths and weights used, so as to make the standard more adapted to decimal figuring.

As the alterations thus arranged for were slight, and as the changes in the values for length and for weight were fairly relative to one another, and therefore made little commercial difference in the yardage per pound, or the meters per kilogramme, of any given number, and as silk could still be bought and sold on the same denier sizes as in the past, the silk trading community agreed to accept the modifications.

The denier system, or denier-aune system, as it is often called, for numbering silk yarns, has always been that of a fixed length and a variable count, and for this reason it lends itself well to the showing of the degree of variation and irregularity incident to this class of material.

The denier was a small French copper coin, of which twelve made a sol, or sou. There were two sorts of deniers, the one Tournois (of Tours) and the other Parisis (of Paris), the latter being worth one quarter more than the former.

The sol was made of copper, mixed with a little silver, and was worth the twenty-third part of an English shilling. It was also called "douzain" from its being divided into twelve deniers Tournois.

The weight of this denier was 24 Paris grains.

The French, or Paris, table of weights of the period was known as the "Poids de marc" table, and in this the grain was the unit, this Paris grain being the equivalent of 0.8197 English troy grains, of which there are 7,000 in a pound avoidupois.

At the same period, there were in use in Italy (Genoa), two weights: one, the Peso Grosso, or heavy weight, employed in the weighing of ordinary commodities; the other, the Peso Sottile, or light weight, used for gold and silver, and for the finer and more valuable commodities, including silk.

The pound weight of the Peso Sottile was the equivalent of the Paris weight of 1 marc, 2 ounce, 2½ gros, and 30 grains, the total being equal to 4,899.22 Paris grains. This pound was divided into 8 ounces, each ounce into 24 deniers, and each denier into 24 grains. The weight of this Genoa denier will be seen, when figured out, to be equal to 25.51 Paris grains.

Here, therefore, we have these two silk producing countries, both having a denier in use, one using it as a coin and the other as a weight, and both dividing it into 24 grains of very similar gravity. Hence, a system of counts, based upon the weight of the denier, would readily find acceptance in both countries.

So much, at the moment, for the basic weight. Let us now proceed to consider the length.

This is based on the "Aune," or "Ell."

The name is derived from the Latin "Ulna," meaning the elbow. It had, for instance, as one meaning, the length of what a man could clasp in his two arms. This measure was in general use in many countries, and districts, and varied greatly from place to place, and in France it varied from the Paris aune of about 42¾ English inches, to the Calais ell of about 68.4 English inches.

The length of the aune, that was formerly in the most general use throughout France, is stated to have measured 3 Paris feet (pied), 7 Paris inches (pouce), and 8 Paris lines (lignes), this being equal to 46.53 English inches. This was the old aune; the French "aune usuelle," or "nouvelle," measured then, it is stated, about 47¼ English inches.

I may here point out that it is a matter of the most extreme difficulty, or even a practical impossibility, to ascertain the exact equivalent of measures that are based upon different standards, even when we know precisely what those standards are, and no two investigations are likely to arrive at exactly the same conclusion.

This is evidenced by the fact that different eminent authorities disagree as to the exact length of the meter in English inches. For this measure the writer accepts the length of 39.370432 inches per meter, which is a very widely used constant.

The exact length of the aune was similarly open to question. The Lyons Conditioning House informs me that the length of the aune which was used in these measurements was 1.1884 meters, which is equivalent to 46.79 English inches. The Encyclopedia Britannica, eleventh edition, 1911, gives the value of the aune of France as "1.885 meters (A. D. 1812)."

Having disposed of these preliminaries as to standards we will continue.

The old method of determining the size of the silk, or sizing it as it is called, was to measure off 80 skeins of 120 aunes each, making a total length of 9,600 aunes, and, using as weights the copper coins known as deniers, weighing 24 Paris grains each, seeing how many of these coins it took to exactly balance the skein, and then the size was stated as that many deniers.

Thus, if 14 of the coins just balanced it, it was a 14 denier silk; if it was lighter than 14 but heavier than 13 it was a 13/14 denier size, and so on.

Toward the end of the eighteenth century, an observant silk merchant, who is said to have been a certain M. Matley, realizing the inconvenience and expense of making such long reelings for sizing tests, and seeing that both the 24 grains of the denier and the 9,600 aunes of the silk, could be exactly divided by 24, and that they would still bear the same relationship to each other, conceived the idea of taking for the weight 1/24 of the weight of the denier, or 1 Paris grain, and for the length of the test skeins 1/24 of the 9,600 aunes, being 400 aunes instead, and he is said to have devised a suitable apparatus for measuring these 400 aune skeins.

The trade willingly accepted the change, and, as the relationship of length to weight was just the same, the old method of expressing the size in deniers continued, although the weighings were then being made in grains.

When, following the French Revolution, the metric system was adopted by the government of France, the silk people went on sizing their silk in deniers as of old, the only modification being that they converted their former standards of length and weight into their metric equivalents, and used them as before.

The length of the 400 aunes, at 1.1884 meters per aune, was 475.36 meters, and so a length of 476 meters was taken as the standard for measurement, this, on account of its easier divisability, being a more convenient number than 475, and as the Paris grain corresponded in weight with a metric equivalent of 0.0531 grammes, that was the value adopted for the weights.

Taking, as the length of the meter, the very usually accepted equivalent of 39.370432 inches, we come to a length of 520.565 English yards as the equivalent of the 476 meters.

The equivalent of the weight of the 0.0531 grammes, is, as stated before, the 1/24 of a denier, or 1 Paris grain, this in turn being equal to 0.8197 English troy grains, of which there are 7,000 in the pound avoirdupois. The more exact equivalent of the Paris grain is 0.053117 grammes.

Under this system, the yardage per pound of a 1 denier silk would be as many yards as 520.565 multiplied by the number of times that 0.8197 would go into 7,000. Thus, 7,000—0.8197 × 520.65 = 4.445474 yards per pound for silk sizing 1 denier. This is a length of 2525.84 miles.

Of course, there is no 1 denier silk, as the thickness of the ordinary single cocoon filament would generally be two or three, or more times that size, and, even then, single ends are too delicate to work alone, so it is necessary that several cocoon threads should be joined together in the reeling to make a thread of suitable size for manufacturing.

In practice, an 8-10 denier silk is about the finest reeled, and it is very rare that as fine a size as this is handled in the United States.

In the year 1900, there was held in Paris one of the congresses before alluded to, at which some modifications of the existing standard were agreed upon, the changes affected being brought about by reducing both the standard length and weight in a somewhat similar degree.

The length to be measured was brought down from 476 meters to 450 meters, or about 5.46 per cent, while the weight used was reduced from 0.0531 grammes to 0.05 grammes, a reduction of about 5.84 per cent.

Since then, this modification has received general acceptance and the count of all raw silk is now based upon this revised standard, which is the number of half decigrammes that a skein of 450 meters weighs, the size being still expressed in deniers.

The weight of a metric gramme is equal to 15.43236 troy grains, which would make the kilogramme 15,432.36 grains, and this, divided by 7,000 grains per pound, gives 2.204626 (usually expressed as 2.2046) pounds, as the weight of the kilogramme.

The decigramme, or 1/10 of the gramme, is therefore equal to 1.543236 grains, and the half-decigramme weighs 0.771618 grains. The 450 meters equal 492.1304 yards.

Dividing 7,000 grains per pound by 0.771618 and multiplying the number found by 492.1304 yards, we get 4,464,531 yards as the length of a pound of 1 denier silk, the same being 2,536.67 miles.

The book, "The Value of Conditioning," published by the United States Conditioning and Testing Company, gives a length of 4,464,528 yards, a difference in figuring of only 3 yards.

In expressing the size in deniers, an 8-10 denier silk should run between 8 and 10 deniers; a 13-15 silk, from 13 to 15 deniers. A silk of this sizing must not be finer than 13.50 deniers, or coarser than 14.50.

By dividing the yardage per pound of a 1 denier silk by the denierage of any given size, the result will be the yardage per pound of that silk.

The difference between the revised standard and the old one amounts to less than 0.0043 per cent, or about one two-hundred-and-thirty-third, and this is a most trifling difference. A silk that formerly sized as 14 deniers would now be 14.06 deniers.

As one test only of the size of a silk would be wholly insufficient to properly show the yardage per pound of such a variable material, the accepted method is to draw ten skeins from different parts of the bale, and make three reelings from each, or thirty in all. The average size of these is stated as the denierage of the silk, while the sizes of the individual reelings show fairly well the degree of irregularity of the material. This variation, or "spring," is called by the French "6eart."

The Conditioning House in New York makes a further excellent test of 10 reelings of 4,500 meters each, for showing more surely the average size, as these long reelings over-run the varying inequalities in size, and this new test (the Compound Sizing Test) is much more dependable where length per pound is wanted.

The old test shows the variableness of the size much better, so the use of both of them is valuable.

In view of the fact that the new system is now firmly established in all the silk-producing countries, it may properly be regarded as permanent.

Autochrome Exposures by Flashlight

MR. W. WEISSERMEL reports, in the *British Journal of Photography*, on some experiments made by him in regard to the use of flashlight in exposures with autochrome plates. After trying different powders, the author finally found that the most satisfactory results could be obtained by means of a flash powder made according to the Lumière instructions, but taking somewhat more potassium perchlorate, namely, 5 parts of magnesium to 3 parts of potassium perchlorate by weight. Aluminium may be used, which must be perefectly free from dust and grease; but the author prefers magnesium, as it gives less smoke.

As regards the quantity to be employed, the author recommends, at a distance of 10 feet from the subject, and with an aperture of 6 to 7, 10 grammes of the magnesium mixture. Of the aluminium mixture somewhat more must be taken. More powder must of course be taken in the case of dark colored objects.

For light filters, either the Lumière or the Geka filter is recommended.

In the development of autochrome flashlight exposures it is best not to use the metroquinone ammonia developer. It works too hard and requires too large a quantity of flash powder. The author recommends pyrocatechin developer, made with somewhat more than the normal quantity of pyrocatechin, as follows:

Water	100 cubic centimeters
Sodium sulphite anhydrous	12 grammes
Pyrocatechin	5 grammes
Caustic soda	3 grammes

Dissolve the sulphite and developer in 75 cubic centimeters of water and the caustic soda in 25 cubic centimeters of water, then mix and dilute with from 5 to 6 times the bulk of water. There is no need to add bromide if the dark room light is perfectly safe; otherwise, add 4 to 5 drops of 10 per cent potassium bromide solution per 100 cubic centimeters of developer.

Smokeless Chimneyless Steam Plants

Forced Draught Reduces Smoke Production to a Minimum

THE accompanying illustrations (Figs. 1, 2, and 3) show the German smokeless steam plant of the Stadt Elektricitätswerke Lichtenberg, and the interesting equipment of the boiler room with an induced draught installation of the Deaque type which is largely replacing the exclusive natural draught of brick chimneys of former days.

Even existing electric light and power stations having large chimneys already in service are employing artificial draught to advantage, as indicated in drawings Figs. 4 and 5, during the peak of the load, the induced draught plant being disconnected during the light load periods. This is an excellent method of regulating the production of steam to meet the actual demands of variable load in the station.

The employment of artificial draught reduces the smoke production to a minimum, so that neighboring buildings are protected from the smoke and soot nuisance.

The photograph (Fig. 1) shows the steel outlet stacks of the municipal electric station at Lichtenberg, while Fig. 2 shows the boiler room with the induced draught plant in the background, the details of the electric-driven fan coupled directly to a three-phase motor being noted in photograph (Fig. 3). The writer is indebted to Engineer Otto Brandt of Berlin-Charlottenburg for the accompanying photographs and data of this German induced draught installation.

It is well known that in former days the natural draught of brick chimneys was employed exclusively, but, in more modern times, induced draught plants have steadily grown in favor. No doubt, compared with the chimney draught, the artificial draught provides improved utilization of the waste gas heat; an inferior grade of fuel can also be used, and weather conditions cannot exercise their prejudicial influence. The intensity of the draught can also be increased with an artificial draught plant, whereby large quantities of steam can be produced during the short periods an engine must work under maximum pressure, without the necessity of installing an extensive battery of boilers.

Furthermore, artificial draught provides a satisfactory solution of the problem how to obtain increased intensity of draught when engine and boiler plants must be enlarged or economizers adopted in older works. A further point in favor of an artificial draught plant, when erecting new electric works or other power stations, is the fact that a brick chimney would often depreciate the architectural unity of the building itself, and of the neighboring streets and surroundings.

It is clear that in mining districts artificial draught plants must be given the preference to a chimney draught on account of their much smaller weight, with the natural consequence that lighter foundations are required, so that all fear of land subsidence is removed.

The main forms of artificial draught plants for steam boilers are plants with direct and indirect draught. Artificial draught plants with indirect draught consist of a ventilator which, by means of a nozzle, forces an air current of a certain pressure into a specially shaped outlet pipe, whereby a partial vacuum is produced in the latter, sucking up the waste gases and discharging them into the atmosphere at a suitable elevation. The action of an induced draught plant with direct draught rests on the principle that the waste gases pass an induced draught ventilator, by which they are forced into the open air through an outlet stack.

It will be seen that the municipal electricity works in Lichtenberg, near Berlin, furnish an example of special interest of an induced draught plant for extensive steam boiler installments. This induced draught plant is calculated for four large double Steinmüller boilers, of which three have been installed. These three Steinmüller boilers have been equipped with three superheaters of 1,250 square feet heating surface each, in such a manner that the steam, with a pressure of 13 atmospheres above atmospheric, reaches a temperature of 350 degrees Cent. The heating surface per boiler is 3,810 square feet and the normal production of steam 19,200 pounds, which can be increased to a permanent maximum of 23,100 pounds, and temporarily to 27,000 pounds.

The preheating of the feed water is effected by three

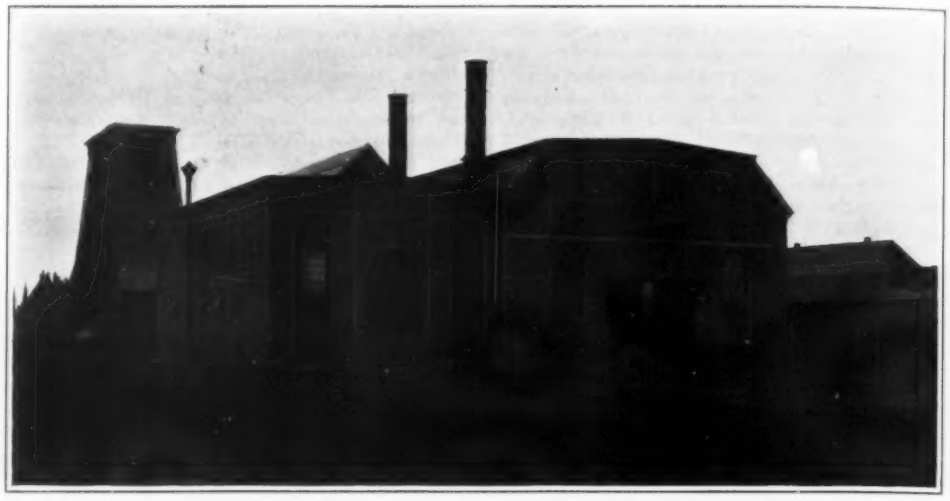


Fig. 1.—Municipal Electric Light and Power Station at Lichtenberg, Showing the Small Outlet Stacks of the Induced Draft System.

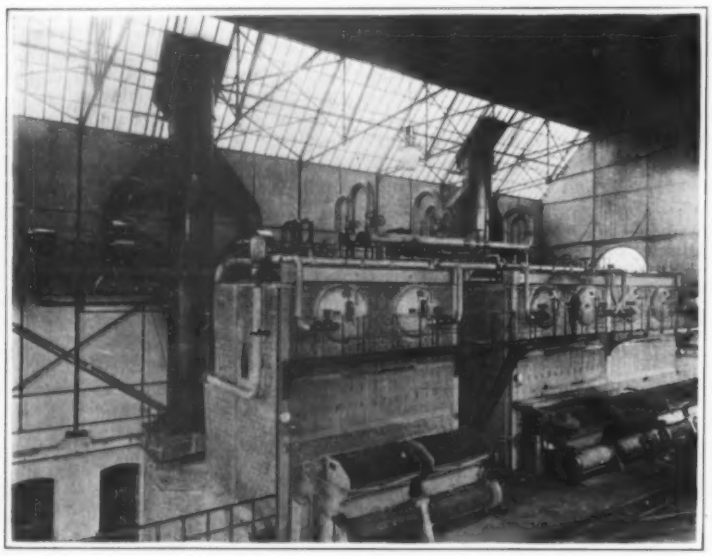


Fig. 2.—Boiler Room of the Electrically-Operated Induced Draft Plant, at Lichtenberg.

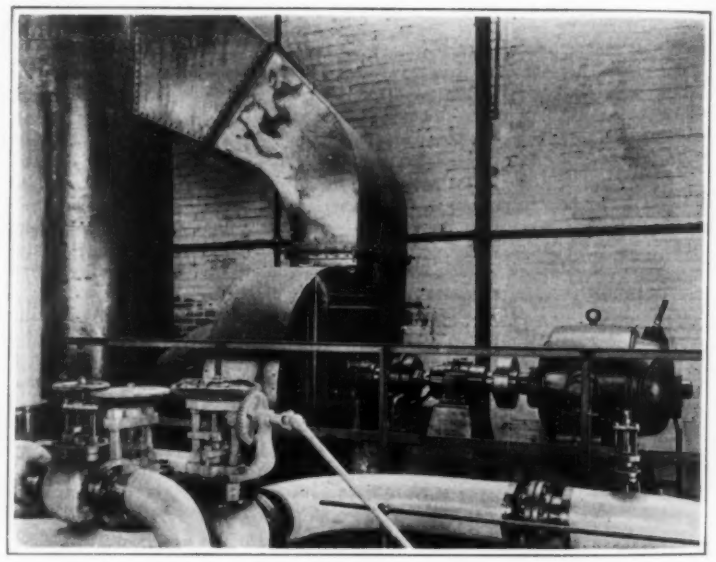


Fig. 3.—Three-phase Electric Motor Directly Coupled to the fan which produces a forced draft.

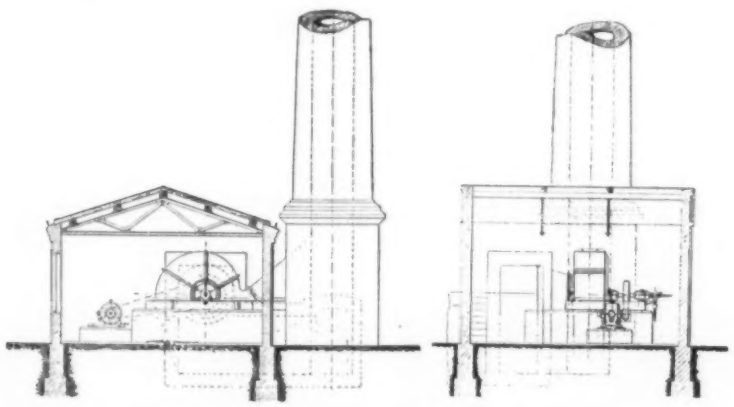


Fig. 4.—Elevation of Plant with Combined Natural and Forced Draught.

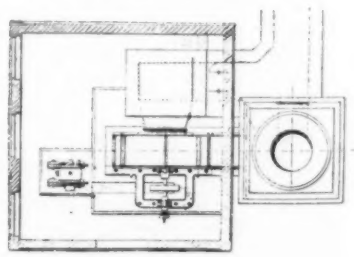


Fig. 5.—Plan View.

economizers of 2,160 square feet heating surface each, and these heat the feed water to about 100 deg. Cent. before mixing with the boiler contents. Each boiler, with an hourly consumption of coal (upper Silesian nut) of 3,300 pounds and a heating value of 7,000 calories, is charged by six mechanical stokers.

There is a ring riveted on the base for the attachment of each stack, and bolted on an iron bed-plate, while two induction draught ventilators are connected with each outlet stack, so that each double boiler can be singly served by one induction draught ventilator.

There are reversing flaps arranged in the outlet stacks, and slides in the induction draught ventilators, so that the induction draught plant can be disengaged when the load falls below 1,100 pounds, when the natural draught can come into action. Such fluctuations occur in the Lichtenberg station, for instance, during the intervals between the working hours of the large consumers, such as the factories supplied with power.

During these periods the induction draught plant is disengaged, and the natural draught substituted, so that an excellent method is available for regulating the production of steam to meet the actual demands. When the plant is under full load the induced draught plant allows of a great increase in the intensity of the draught, quite independent of the weather conditions and the amount of moisture in the air.

The induced draught fans are of special design, to deal with the circulating waste gases. The bearings are protected against overheating by means of a reliable system of water cooling for the shaft. The power required for this induced draught plant is not quite 1 per cent of the engine output. The drive of the four induced draught fans is provided by direct coupling with electric motors, comprising two three-phase current, and two direct-current, shunt-wound motors of the Siemens-Schuckert type.

It is claimed that tests have shown that the boilers are capable of producing 7.1 pounds of steam per square foot of heating surface per hour, and 1 pound of coal, 9.75 pounds of steam. The consumption of steam per kilowatt hour is 13.75 pounds, under full load. Under usual conditions with an average load of 1,050 and 270 kilowatts, night load, 2 to 2.5 pounds of Silesian nut coal are required to produce one kilowatt hour.

The drawings (Figs. 4 and 5) show an older steam boiler plant, for which the natural draught with a brick chimney proved inadequate, and led to the successful adoption of artificial draught, being installed without any great alterations. The waste gases are drawn off by a special induced draught ventilator which forces these gases into the existing chimney. The blowoff opening of the induced draught ventilator slants upward and is directly connected with the chimney by a connection piece. The lower part of the induced draught fan is carried out in cement work and the drive is effected by a belt drive and electromotor.

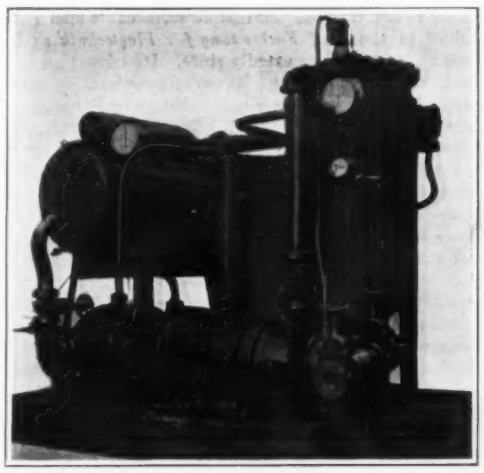
Cooling Ammunition Quarters on French Battleships

To Eliminate One Possible Cause of Explosions

By the Paris Correspondent of the Scientific American

SINCE the explosion of the "Liberté," resulting in the loss of one of the leading units of the French fleet, beside hundreds of lives, the question of cooling the ammunition quarters on board the battleships has been fully discussed. It appears to be evident that much too high a temperature is allowed in these quarters, and this is one cause at least which may contribute to bring about an explosion of the powder. The efforts of the navy department are therefore directed toward remedying this condition of peril. However, the question of cooling the ammunition holds is not a recent one, and for some time back the leading governments of Europe have had it under consideration. In France, the newer battleships "Danton" and "Suffren" have a very efficient cooling method applied to their holds. It is the Leblanc refrigerating system and is to be used on at least eight of the battleships of the navy. As will be remembered from our detailed description of this method, the cooling is obtained by the self-evaporation of water in a fine shower when a current of air is forced through it. It is a familiar experiment to evaporate a liquid rapidly in order to cool it; for instance, when bisulphide of carbon is placed in a watch glass upon a board, having a small layer of water under the glass, and the whole placed under the air pump or blown upon so as to evaporate the bisulphide rapidly, it cools down by its own evaporation to so low a point that the water is frozen under the glass. When we try to produce cold by rapid evaporation of water, it is found that the amount of vapor which needs to be drawn off to give a certain degree of cold is so large that no kind of pump could be made which would take it away rapidly enough. By designing a turbine pump working on a new principle, M. Leblanc succeeded in solving the problem, and can draw off enormous volumes of vapor at a very high rate.

A cooler working on this principle is simplicity itself. All that is needed is a tank having the cooling brine descending in a shower, and an intense evaporation is set up by drawing off the vapors at a rapid rate by the pump. This latter takes the shape of a small rotary pump of a special kind which works in connection with a steam injecting nozzle so as to set up a powerful suction upon the evaporating tank. The brine can be cooled down even to the freezing point of water or below, so that it can be sent into another tank in order to produce ice, or it can be used to cool the air, in which case it need not work at as low a temperature. Our engraving shows a special air-cooling set which has been designed by M. Leblanc in connection with the engineers of the French navy. The object here is compactness and lightness, which gained, gives an outside appearance to the set different from the refrigerating plant which we already described, although the principle is the same. The air coming from the ammunition holds of the vessel is



The Leblanc Group of Cooling Apparatus on the Battleship "Suffren."

heated by its passage through these rooms, and then needs to be cooled by passing into a refrigerating tank. This latter contains the brine cooled as above mentioned, and within the tank are hollow plates or wing radiator pipes through which the air passes. After being cooled, the air is sent again by means of a blast fan into the ammunition rooms, and so on through a continuous cycle. The air-cooling tank does not appear in the present apparatus, and it represents only the part which serves to cool the brine. Sea water can be used to take the place of the brine during the seasons when the water is cold enough to be used for this purpose. An artificial brine is put through a continuous circulation between the brine-cooler and the air refrigerating tank, but sea water is used only once and is not returned to be cooled but is sent directly into the sea, as this gives an economy.

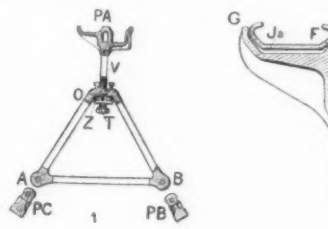
The present group contains no less than four rotary pumps for different purposes, and two of them are driven by the electric motor which is seen at the front part. A second motor at the left hand side of the group serves to drive the rest of the pumps. What is to be particularly noticed in the Leblanc method is the entire use of rotary pumps, a decided advantage, as they have a small size and need much less looking after than machines which have reciprocating motion, and which allow of an electric drive on decidedly better conditions. Another point which will at once appear in favor of the new method is that no chemical products of any kind need to be used for the cooling, and this is a very great advantage for battleships which are required to make a long cruise, inasmuch that they do not need to ship any such products on board during the run. We should mention another feature, this being the light weight of the Leblanc apparatus. In fact this machine weighs only half as much as a carbonic acid machine of equal cooling capacity. Owing to the use of rotating parts running at high speed, there is practically no noise, and this is a good feature on shipboard, especially since wireless telegraphy posts are coming into use. For these different reasons the engineers of the French navy were led to take up the Leblanc system for the battleships, and even before attention had been so strongly called to the question of cooling the ammunition quarters on board, it had already been decided to apply the apparatus upon no less then eight of the battleships, comprising the "Suffren," "Danton," "Courbet," "Vergniaud," "Condorcet," "Jean-Bart," "Mirabeau" and "Diderot." As to the more recent measures which the navy department is taking for cooling the powder quarters, this will lead to the more extensive use of refrigerating apparatus, according to the late decision of the Minister of the Marine. A decision has been made in regard to at least one other unit of the fleet, the "Jules Michelet," and as we already mentioned, Vice-Admiral Bellue made a report in which he showed that the temperature sometimes reached 30 deg. Cent. (86 deg. Fahr.) on this vessel. However, refrigerating apparatus will be installed so as to keep this down below 25 deg. Cent. (77 deg. Fahr.).

The Houdaille Emergency Wheel for Automobiles

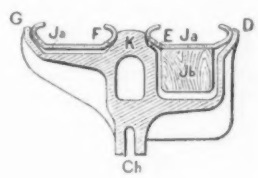
THIS device consists of an emergency tire, fitted with an inner rim, and of a triangular frame of steel tubing (Fig. 1) which carries a double shoe (Fig. 2) at each corner. Two of the shoes are simply hinged to the frame, while the third shoe is attached by a swivel joint to the end of a screw (*V*) which turns in a nut on the frame. By tightening this screw one part (*ED*) of each shoe is pressed firmly against the inside of the rim of the automobile wheel, and the other part (*GF*) is pressed against the emergency tire, as shown in Fig. 3. As the center of a circle is determined when three points are fixed, the emergency tire is thus accurately centered on the axle.

The operation is performed in a few seconds by tightening a single screw, which is then clamped to prevent it from working loose. The tubular frame is light, stiff and strong.

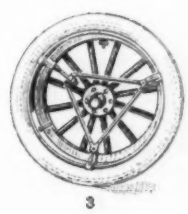
Double pneumatic tires have been used with advantage on heavy vehicles. By carrying four Houdaille frames and four extra tires, inflated and mounted on steel rims, all of the wheels can be doubled quickly when a heavy load is carried. Furthermore, while anti-skidding tires are often required, smooth tires are more satisfactory and more economical for ordinary use. By the Houdaille system the smooth tires of the hind



1



2



3

wheels can be paired with anti-skidding tires when a slippery road is encountered. The device also makes it possible to combine two old tires, neither of which could be employed alone with safety.

The Seventieth Anniversary of the Use of Ether in Surgery

THERE is some doubt as to the date of the first use of anaesthetics in surgery, and it is probable that in some rudimentary form the practice existed even in antiquity. But all the evidence seems to point that the first definite use of ether, according to the present method or its equivalent, was made on March 30th, 1842, by Dr. Crawford W. Long, in the village of Jefferson, Georgia, for the removal of a small tumor from a man's neck. The names of Jackson, Wells and Morton are involved in a controversy which arose a few years later as regards the originator of the use of anaesthetics, but it appears practically beyond doubt that Long anticipated the work of these three by several years. Long was a country practitioner, and this presumably accounts for the fact that both he and his discovery remained in comparative obscurity, though it would seem that he himself did not fully realize its importance.

Motor Flight and Air Sailing or Gliding*

The Ideal is a Machine Capable of Both Kinds of Flight

By Carl von Lilienbach

THE architect Gustav Lilienthal is a worthy heir in Germany of the fruitful deeds of his brother Otto Lilienthal. He seems to have both the *will* and the *patience* to pursue to a successful conclusion the problem of flight without a motor. He calls attention to the almost motionless and effortless flight of the gulls and frigate-birds which follow ships by the hour. To imitate this sort of "air-sailing" the two factors involved are first the upward air-currents which are found very generally not only along the coast but also over level surfaces, and, secondly, very thick and naturally elastic planes so curved as to resemble the wings of soaring birds.

His studies on this subject a year ago in the Society of German Flight Technique seem exact and free from self-deception, and he does not fail to recognize the difficulties of translating theory into the practical requirements of a man-carrying motorless aeroplane.

As the thickness of the planes was made 25 centimeters instead of 5 centimeters, and the forward edge was round, the bird-wing was proportionally imitated and the least possible resistance in the *variable* air was attained. (According to his opinion, in a *steady* wind sharpened forward edges are apparently better than the usual thick edge.) "In air-sailing we seem unable to imitate the flight of the albatross (which has the narrowest wings), but must at first content ourselves with that of the buzzard or the stork.

"Since the man-carrying machine is so much heavier (12 to 20 times) than the bird, it is obvious that there can be no thought of air-sailing without wind, especially with the flying-machines of to-day, burdened with heavy framework and motors. Only by "rowing" flight can we arrive at air-sailing, for we must use the former to arrive at a height where we shall find the necessary wind-strength for the latter. "Rowing" is necessary unless the wind has a rate of over 12 meters per second (26¼ miles an hour)."

Thus Lilienthal's goal is a machine capable of both sorts of flight. But even "rowing"-flight in which the ends of the wings would only have to bend downward like feathers instead of flapping up and down like bird's wings, would be possible only in wind, because of the much higher coefficients of pressure. In this very fact we perceive the relationship between the two kinds of flight, since the irregularly varying lifting force in air-sailing may be regarded as the equivalent of wing-beats, except that these are more regular, more effective, and volitional.

Like his brother, Gustav would make use of a small motor of 1 to 2 horse-power, not to drive a propeller but as a reserve of power for starting the wing-flapping mechanism at the beginning of a flight and also in a calm.

Man wishes to know and will know whether it is possible for him to sail upon the air without effort without the aid of a motor, even if it be only upon certain windy days and in localities where the currents are favorable. Whether this no longer fabulous possibility shall accrue to the use of the man of industry and commerce or only to the pleasure of the daring sportsman is a secondary question. But if I may offer a technical criticism on technical grounds it is against the parallel drawn by Lilienthal and so many aviators between birds and aeroplanes. The outline or profile of the lifting plane and the "front edge" as designed by Lilienthal cannot suffice for so many different conditions as are involved in gliding, air-sailing, and propeller-flight, in variable and steady winds, and motion at different speeds—not even in "motor-sailing-flight" as practiced by me.

Gliding aeroplanes are subject only to the wind of their own specific speed; the air is disturbed as little as possible. In motor-flight the speed is twofold to threefold (24 to 40 meters per second); hence the air is forcibly cut into and thrown downward every second, which creates current conditions essentially different from those that obtain in gliding. Successful builders have long since recognized that flat planes give better results, and some of them (Maurice Farman, Nieuport) even sharpen the forward edge, and these are good machines.

Therefore, if we wish to combine propeller flight and sailing it is preferable to have a flat profile with a thick upper surface, a fact recognized by many scientific and practical men. But it would be still better if we could make the curve and the cutting edge upon whose profile and downward inclination the penetration of the air chiefly depends—*alterable,* in general to do away with the stiff immovable planes now nearly universal.

Herein lies an opportunity for detailed study and experiment on the part of many investigators and inventors. And this brings me to the kernel of my theme. It is necessary to meet the highly variable conditions of wind and wind-pressure with *correspondingly variable surfaces,* so that a harmonious working together of atmosphere and apparatus will be attained. Thus we may achieve the ideal machine, which, economical of power, inspired by the genius of the discoverer, guided by the trained instinct of the bird-man (or perhaps by an automaton), will be capable of every form of flying, sailing, gliding, hovering, at low speed or high, and making use of either general or local conditions of wind.

Such a machine must be very different from anything we have to-day! Does not all experience hitherto indicate that satisfactory and lasting results can be hoped for only from apparatus whose planes and other parts are flexible and alterable?

First, the Wright flyer surprised us by its activity, thanks to its plane warping, the priority of the idea however belonging to Mouillard. Curtiss used first twistable wing-ends, then displaceable auxiliary planes set opposite each other between the ends of the main planes. Wing warping has remained thus far the most important aid to equilibrium; it takes the place, at least in time of need, of the softness and variable width of the bird's-wing.

For the last three years how many authorities in the technical journals have urged us to "Make the wings movable!" (Dr. Loisel, Dr. Amans, and others.) What magnificent progress we may thus hope for if already we get such results with planes that are rigid or three-quarters rigid. Within a few years we may look back upon a Blériot machine with skeptical wonder and find scarcely a man bold enough to trust himself to these stiff planes on the journey from Paris to Rome!

The most decided and effective novelty in movable planes is the variable "extensible surfaces" which I described in the *H P Fachzeitung für Flugtechnik* as far back as 1908, and repeatedly since. Its advantages are most noticeable on an Etrich monoplane specially adapted to the purpose of air-sailing experiments. It may be predicted that with this Austrian apparatus the sailing and hovering flight of the Wrights may easily be excelled, and possibly a system of flight may be worked out which can be employed at least for purposes of sport, especially in seaside resorts and other localities where winds are plentiful. That the Etrich "Dove" is of a higher class and also more stable than the Wright biplane is known. Its peculiar fitness for gliding by the use of variable surfaces is clear when the flights at Kitty Hawk are considered. While in these latter flights two unequal levers—namely, a tail rudder situated at a considerable distance from the metacenter, and a head weight—effected the requisite changes in the gliding angle with reference to the existing air current, and thus brought about a varying loading of the main surface, in the case of the "Dove"—or of a similarly constructed bi-autoplane—reefable surfaces are added, by means of which the specific load upon the surfaces can be so varied and adjusted as to render possible either sailing over a given spot, or rising against the wind, or, when the wings are reefed close and the weight shifted to the head end, to cause the machine to dip downward until, on gradually unfolding the wings and tilting upward the tail, while drawing back the head, the line of flight is changed to the horizontal. The constructive perfection of such an air-sailing or gliding apparatus as outlined by me and the bringing together of the guiding and equilibrating devices (which mutually complete or compensate each other) in suitable controls which can be used separately as well as in unison, will quickly be accomplished by practical experiment.

The influence of this new achievement is bound to be felt, for the constructors cannot ignore the obvious advantages of variable surfaces. Beaumont, the victor in three great circuit flights, in his new book "Mes trois grandes courses," places this variable wing-width as one of the requisites for the perfection of the flying machine.

In motor flight entirely different principles seem to prevail. Since the overpowerful motors of 100 to 140 horse-power have been built, the planes have been shortened more and more in order to lessen the resistance (at once harmful and helpful) and thus secure increase of speed!

This produces great danger in landing, because of the high speed and the diminished possibility of gliding in consequence of the smallness of the planes and the overloading by the motor (usually placed forward). In general there is too great a specific load.

In gliding and air-sailing without a motor the object is to attain a flat gliding angle (the prerequisite for safe landing) by a relatively low specific loading of the planes.

From this it follows that by means of the variable planes the load per square meter can be regulated at will, and correspondingly the possibility of gliding, either in gliders or in motor-driven machines. Also exterior forces in the shape of gusts of wind can be instantly reduced and compensated for, and air-holes can be avoided by quickly changing the course to horizontal flight.

But since the extreme ends of the planes exert the greatest effect on the whole system, the extended or contracted width on either side or both together, must afford the best solution of the problem of equilibrium.

Thus the possibility of sailing and flying through the air by the hour, alternately with or without the motor, in the safest, easiest and most economical manner may be expected to be realized.

The advantages of this variable extension as advocated by me may be thus summed up:

1. Rapid rising by the sudden spreading of the wings on both sides, when the machine is going at full speed, which can be attained more quickly with the reduced wing surface.

2. Safe landing in a slow glide by progressive extension of the ends of the planes after the motor has been checked; hence landing like the birds.

3. Greater security when at rest, as floating on a strong wind, than with machines having rigid planes which are generally over 30 feet in span or even as high as 50 feet.

4. Acceleration of the speed in flight by successive drawing in of the ends of the planes and opening the throttle, i. e., increasing the number of revolutions.

5. Reducing the speed to the critical "v" by extending the planes and at the same time closing the throttle, the adjustment between the two being such that horizontal flight is maintained.

6. Varying the speed between a forced and power consuming rate and a slow, economical speed; and deducing therefrom the given factors, "rate of revolution" and "wing extension," in each case through the variation of "v" for the acceleration or the economical reduction of the flight.

7. Greater ascending speed with partially extended wings combined with the maximum rate of revolution.

8. Reaching greater absolute altitudes, where the rarefied air reduces the degree of effectiveness of planes and propeller, as well as of motor (because of lessened oxygen supply), by means of successive enlargements of the planes or wings by which the climbing angle is lowered and motor power saved. The adjustable wing extension also makes it possible to reach greater heights with a relatively weaker motor.

9. Swifter gliding (plunging) from great heights with the certainty of never failing to change into a slow glide at an angle of ten degrees, and thus being able to select a desirable landing whether the motor is going or not.

10. Rising with a greater load in case of necessity (with full spread of wings), than would be possible with a smaller spread.

11. Regulating the speed in proportion to the weight carried and with special reference to the oil and gasoline consumption.

In a flight of several hours duration, in which 200 to 300 kilogrammes of supplies are carried, one is able, therefore, after a few hours, to increase the speed not only because of the reduced weight, but by the lessening of the spread. Thus Gobé, e. g., on a Nieuport, on December 23rd, 1911, with a full load of 325 kilogrammes, flew 8 hours and 16 minutes, making 87 kilometers per hour at the beginning of his record flight and over 97 kilometers per hour toward the end. By a still further reduction, of the spread, which was only 7 meters, he would have been able to make 95 kilometers after the fourth hour and far more than 100 kilometers at the end.

12. The bad effects of striking wind puffs and dangerous descending air currents known as "air pockets," as well as oblique or side winds, are readily compensated for by the almost automatic extension or reduction in area of the wings.

13. Great economy, throttling the motor, or temporarily stopping it, utilizing thereby the active energy of the wind puffs and currents for supporting the aeroplane. Less energy is consumed and less strain is made on every part of the machine, engine, and propeller than would occur if the whole were forced against the air currents. It is the science of intermittent motor flight and gliding.

14. Eventual possibility of "effortless air-sailing" and soundless hovering or approach of a given spot without expenditure of power; of great value for military scouting or actual attack of troops or air craft passing underneath, as well as for acoustic communication with friendly forces or for the release of carrier-pigeons.

15. All problems of stability, whether increased speed assists stability in a wind or not, seem simplified by the various factors in the machine, since longitudinal and lateral stability are indubitably assured by means of the variable surfaces.

In short the introduction of these variable factors to the flying machine constitutes *the essential solution of the problem of flight.*

* Abridged from *Fachzeitung für Flugtechnik.*

Among the completed constructions which carry out my ideas may be named: Monoplane of Pfitzner which had displaceable wing-tips but did not have variable surfaces. In making curves this machine flew excellently. The multiplane of Burkart had displaceable parts of planes. Similar is the biplane of Lefebre in Lyon. A peculiar construction, in some respects comparable to that of a bird with wing-ends and tail capable of being drawn back, is that of Ridingmaster Schmidl, which has already achieved success. Very original is the June-bug-like monoplane of Marcay-Moonen, whose planes can be drawn back completely into a slanting position, whereby the angle of attack of the two surfaces may be altered with relation to each other at the will of the operator.

Recent Cancer Research—I*

And Modern Views Regarding the Nature of the Disease

By W. R. MacDermott, M.B.

THE lay reader may find in his native modesty a reason for hesitating to interest himself in a subject so technical as the origin, nature, and cause of cancer. If, however, the Book of Revelations, Browning's Poems, and the Insurance Act, not to speak of what passes as Social Reform, fascinate him, he need not, through mere diffidence, decline considering a few comparatively simple facts touching a disease, important as taking 40,000 lives every year in these countries, and the study of which brings peculiarly into view the ever-interesting problem of the nature of life and death.

We must begin by saying that recent studies of cancer do not at all discredit the conclusions as to its nature arrived at by the older physicians, many of whom showed critical observation, joined with a power of anticipating knowledge of facts by penetrating, though speculative, reasoning. They had, however, a much easier task than their successors, who are confronted with an accumulation of facts and theories beyond their powers of co-ordinating and interpreting them, facts leading away from the subject into wide and only very partially explored scientific fields. The older physician lived and thought in the sensible plane, and if he realized the infra-sensible at all, ventured into it with apologetic caution. He described, and described well from accumulated clinical experience, limited to the human subject, using the language of sensible observation, cancer, in its first stage, at least, as an abnormal element of structure. He included, and even associated it with, a group of such abnormal structures, such as warts and moles; it was simply a piece of aberrant or misplaced structure at first, very minute, and which might remain dormant a lifetime, or an indefinite time, giving rise to no obvious signs of disease. But disease, when it did arise, was always traceable to some such minute abnormal piece of structure liable to take on the pronounced diseased form with advancing age, local irritation, and other exciting causes. The form itself became malignant through dissemination of the elements or products of the primary structure, as it grew and degenerated *in situ* poisoning or vitiating the tissues and humors. He recognized spontaneous cure and effort at such cure, but as occurring with such rarity as to suggest error in diagnosis. He was familiar with a long list of vaunted remedies coming into vogue, only to be discarded as failures. These he looked on with tolerant scepticism, unwilling to close the door on a possibility so much to be desired. The only remedy that stood the test of experience for him was the surgeon's knife, and that only when the abnormal structure was localized and accessible.

This description, freed from the accretions of thought which went with it, has the same intrinsic value as ever it had, and, in particular, from the practical point of view, the last statement. But without being invalidated or contradicted in any essential respect the description has been vastly expanded, indirectly by the general enlargement of scientific knowledge, and directly by the special investigations of cancer. What the older physician took loosely as an element of bodily structure has been identified as a cell, or cell aggregate, a cell being a determined physical form of microscopic dimensions capable of independent or singular existence as such. The plant was first determined as a cell system, and the conception once formed was extended to cover all forms of life. But the cell, itself a living form, was from the first determined to be a complex structure, and, though extremely varied and varying, had a common mode in life. Reduced to its simplest form it is a minute mass of so-called living substance or protoplasm. Protoplasm in its turn exhibits indications of structural differentiation, and biologists, preoccupied with the idea of a unit of life, state granules appearing in it as bioblasts or the ultimate vital units. If such a unit is to be predicated at all a man, or an oak tree, is as much a vital unit as a cell which often, as in the case of seeds, spores, and as modified in bone, woody fiber, or full of fat, starch, and other matters, do not exhibit any of the phenomena of life. In point of fact the extension of scientific knowledge has gone far to substitute a negative for a positive definition of the term life, to state that it cannot express in the older sense any disposition whatever of material particles as "living" structure. The evidence for life is the same, whether shown in a man's house or a spider's web, or in the body of the man or spider. If the material details of the latter could be brought into the same sensible plane as the former we would not be able to say that one was alive otherwise than in the sense the other is, that is, as showing apparently antecedent design or purpose. There is only one part of physiology, a recent writer[1] remarks, which is not yet accessible to our methods, and which we cannot prove to be governed by the laws of inanimate nature. These are the psychological phenomena. We may be excused saying this much, since mental causes have been ascribed to account for cancer and other structural diseases. Allowing that a person, knowing he has cancer, is influenced thereby, mentally and physically, a discussion of the nature of such influence would be out of place here. Men die of cancer without knowing either the disease, or what is the matter with them. The experimental investigation of it has been carried out in animals, such as mice, and it is not impossible that it may yet be carried on *in vitro*.

What the older physicians identified as a minute element of abnormal tissue, the cell theory enabled the later to specify as a living cell, living in the same sense as the other cells of the body, and containing, like them, living substance or protoplasm. It could only doubtfully be specified as an aberrant or specific cell, since it approximated indefinitely, even under pronounced conditions of variation and disease, to the cells of non-malignant tumors, and to normal cells. One hypothesis, indeed, was that it was an embryonic cell, or a reversion to the embryonic type, a type which, however, covers many cell forms. The limitation to the human species was soon abolished, and the disease determined as occurring in many species of the five great orders of vertebrata. With the doubtful exception of reptiles, in fish, amphibia, birds, and mammals.

Another great step toward advancing our knowledge was attained by the experimental inoculation or transplantation of the cancer cell from one animal to another. This method rests on the fact that the cell remains alive for some time, apart from the cell system from which it has been taken, so as to be able to proliferate in the system to which it is transferred. The cell system in man, and indeed in all animals, is greatly differentiated, so that a cell normal in one site is abnormal in another, which, however, does not exclude altogether its ability to live in such site; tissue elements, thus normal in themselves, are often found in abnormal sites, evident in the sensible plane in the case of moles and cysts. It is not an extreme supposition to make, that as no two men are exactly alike, so every cell in a man's body has a distinct individuality of its own beyond us in the infra-sensible plane. The cell grouping into specialized organs and tissues is specific again, not only for the individual cell, but also for the cell-group and for the whole cell system. It does not follow, therefore, that there is absolute indifference to transfer of apparently similar cells from one man to a similar site in another man. The thing can be done with normal cells, with varying measure of success for special cell aggregates, such as skin tissue and blood cells, failure usually attending transfer in general.

But while transfer of normal cells from one animal to another of the same species is possible under qualification by the specific individuality of each animal, it is found impossible to transfer such cells from an animal of one species to another of a different species. This is remarkable, since altogether foreign cells, such as bacilli and protozoa, can exist in a wide range of species, preserving their own specific identity. As far as known the cell proper to a species can live only in animals of the species; transferred to another species it dies, not, however, without producing some effect on the organism it enters. The theory of resistance and immunity rests, among other factors, on this observation.

The animal cell is either unicellular, or a member of a cell system in inter-dependence with other cells. In reproduction the former sub-divides into two or more cells, which separate and lead, as distinct individuals, distinct lives. This form of cell is said to be immortal, as merely dividing into similar cells, but, as is evident, the loss of individuality by the parent cell means its death, as far as identity is concerned. When the cells remain in union, forming a metazoan or connected system, the system becomes a distinct individual, mainly through the component cells, or great numbers of them, retaining identity as a fact of localized disposition. The system originates, apparently, by the same process of division, which the unicellular organism or protozoon exhibits; a single fused or conjugate cell successively subdivides becoming differentiated into the organs and tissues of the animal body in the process. Once this ontogeny or cell differentiation, following a definite routine, is completed, the division or proliferation of the tissue cells is arrested or restrained, they become fixed, each in its proper site, and under constraint by their environment obtain identity of place and position, maintained by a process of interstitial replacement. According to one writer, Francke, there are 4,000,000,000,000 of these fixed cells in the human body, as against 22,500,000,000,000 motor or blood cells, which, however, are constrained by the channels in which they move. Now, suppose these figures to represent particles of dust or sand, what would be the chance of each particle finding and keeping a definite place, so as to eventuate in a systematic arrangement?

The systematic arrangement or ontogeny of the metazoan organism proceeds from a very simple step to steps infinitely varied, but each step appears to be determined by its immediate antecedent. The fertilized ovum or egg-cell divides into, say, eight distinct, apparently precisely similar, cells. It is held, however, that only one of these, the embryonic or germ-cell preserves identity or individuality in the process of proliferation. This is one of the forms the elusive idea of a vital unit takes, and we may pass it by with a note of interrogation. The hen's egg is a group of living cells starting, say, from eight primordial cells, one embryonic, the others trophoblasts, so-called because supposed to serve as nutriment for the embryo, represented by the chick. The hypothesis implied here is in flat contradiction to the whole tenor of cell physiology. In the developing egg the process of cell proliferation, common for all the cells, proceeds up to a certain limit beyond which the whole egg-cell system passes into a resting or quiescent stage, in which it may remain an indefinite time. When the next step in development occurs two suppositions may be made, one that the embryo or chick absorbs or devours the yolk cells, these being killed thereby, the other that these cells are transformed into the tissues of the chick, preserving their specific vitality in the process, that being throughout autogenetic in the egg, and not implying cell death.

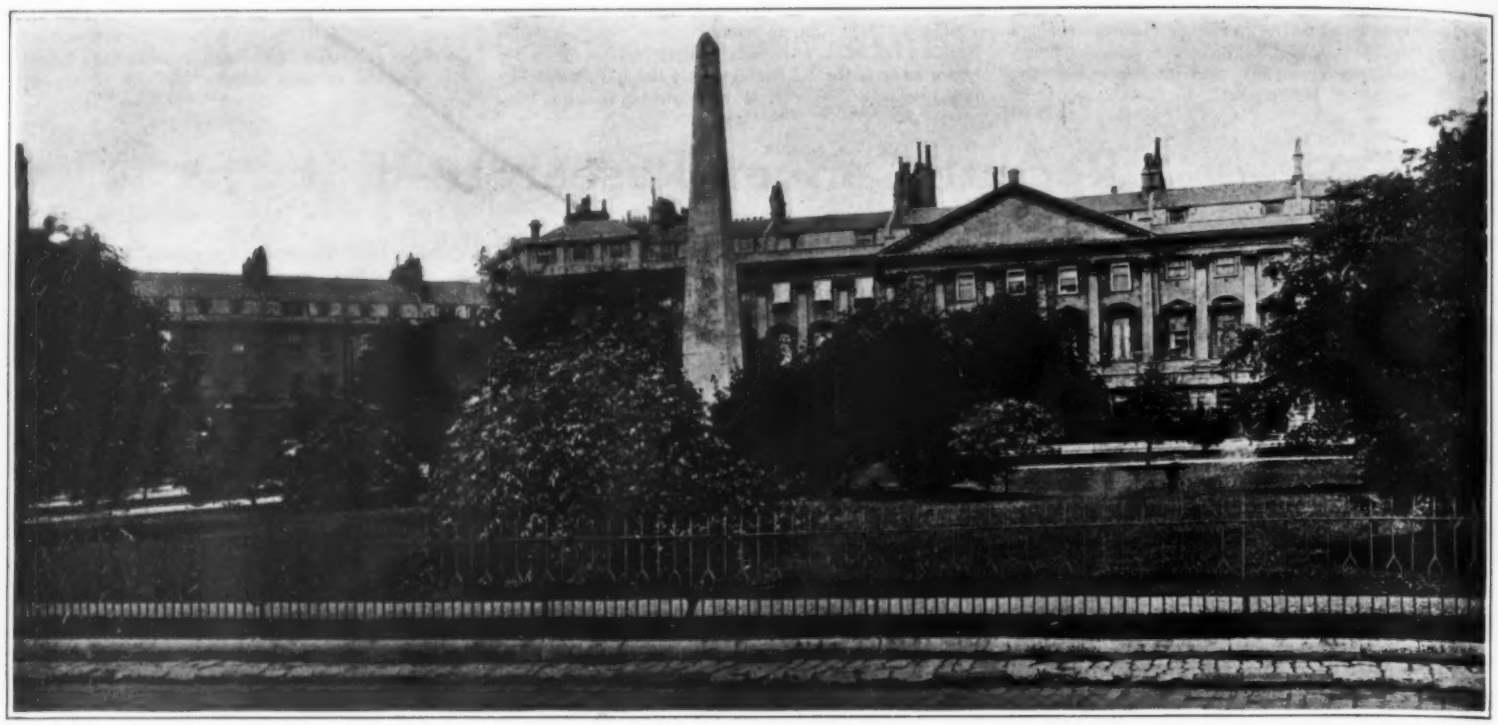
The first supposition forsakes the basis of ontogeny for a crude observation of the manner in which animals feed themselves on dead, organic matter. The second introduces nothing new, but adheres to the connected fact that the cell proliferates, and in proliferation is transformed into nervous, osseous, cartilaginous, connective cutaneous, and other tissues, remaining as much alive as ever it was, that it is able to continue, on occasion, the process of proliferation or reproduction, although greatly differentiated in these tissues. Again, it exhibits the property we have seen in the egg of remaining an indefinite time in the resting or non-proliferant state. The cells of the human central nervous system, whether exercised or not, are, in particular, in that state; they are born and die with a man, and under normal conditions never proliferate or undergo transformation.

It would be incompatible with the integrity of the metazoan organism that the cell should lose its vital individuality; it remains in the fixed or resting state without, in general, losing the original power of proliferation which determined it to a particular tissue and site. It departs from this determination on the microscopic scale we cannot say how far, and with what consequences. In the sensible plane the ovum and its primary segmentation is often found blighted and deformed, whole organs defective and transposed, and bits of tissue misplaced, forming congenital tumors with which cancer is frequently associated. One of the theories of the cancer cell, resting on its structural form and its extreme proliferation, identifies it with the embryonic cell type. The embryonic cell, however, is polymorphic, assumes the form of almost every normal tissue cell, occurs in every part of the body, and proliferates as the other cells do under like conditions.

To be continued.

Reproduced from the *Westminster Review*.

[1] Prof. Czarpek, "Chemical Phenomena of Life." Harper Bros., London and New York, 1911.



Queen Square, Bath, England.

From the Days of the Romans

Radium in Historic Bath Waters. Sir William Ramsay's Additional Discoveries

By P. F. Mottelay

WE gave, not so long since, a biographical account of Sir William Ramsay, F.R.S., President of the British Association, and followed it by reports of interviews with him concerning his new power scheme, which, in the opinion of many scientists, promises to do away with coal strikes and possibly with coal mining altogether.

The press generally has been advising the public of the very numerous and very valuable investigations Sir William has carried on in many important channels. The scientific world knows that, jointly with Lord Rayleigh, he discovered, during 1894, the element *argon*, of which the existence had first been suspected by Lord Cavendish. In the year following, he personally obtained from cleveite another gaseous element *helium*, hitherto unknown in terrestrial matter and which had first been recognized only in the sun during the 1868 eclipse in India. Helium, like argon, is one of the "inert" gases forming no chemical compounds and, therefore, possessing no therapeutic action. During 1898, in conjunction with Dr. M. W. Travers, he discovered three more gaseous elements, which were called *neon*, *krypton* and *xenon;* and, with the aid of Mr. Frederick Soddy, he has since found that radium actually evolves helium through a spontaneous change in the radium emanation. But only a few people are aware of Sir William's late additional discoveries, in connection with the hot mineral waters of the historic city of Bath which he found to contain distinctly both helium and radium.

Bath, in Somersetshire—the "Aquae Solis (Sulis)" of the Romans, also called the English Teplitz—is the only place in Great Britain where natural hot mineral springs are found. The city is located in a very pleasant district on the Avon, eleven miles west of Bristol. It stands at an elevation of 100 to 600 feet above the level of the sea and the temperature of its hottest spring is 120 degs. Fahr.. the same exactly as that of the hottest at Teplitz-Schönan, the oldest spa in Bohemia, situated at an altitude of 730 feet. The Bath waters resemble closely those of the celebrated Lenkerbad (Loèchs-les-Bains) in the Canton Valais, Switzerland, at the foot of the Gemmi Pass, and are popular for their curative properties, especially of gout and kindred complaints.

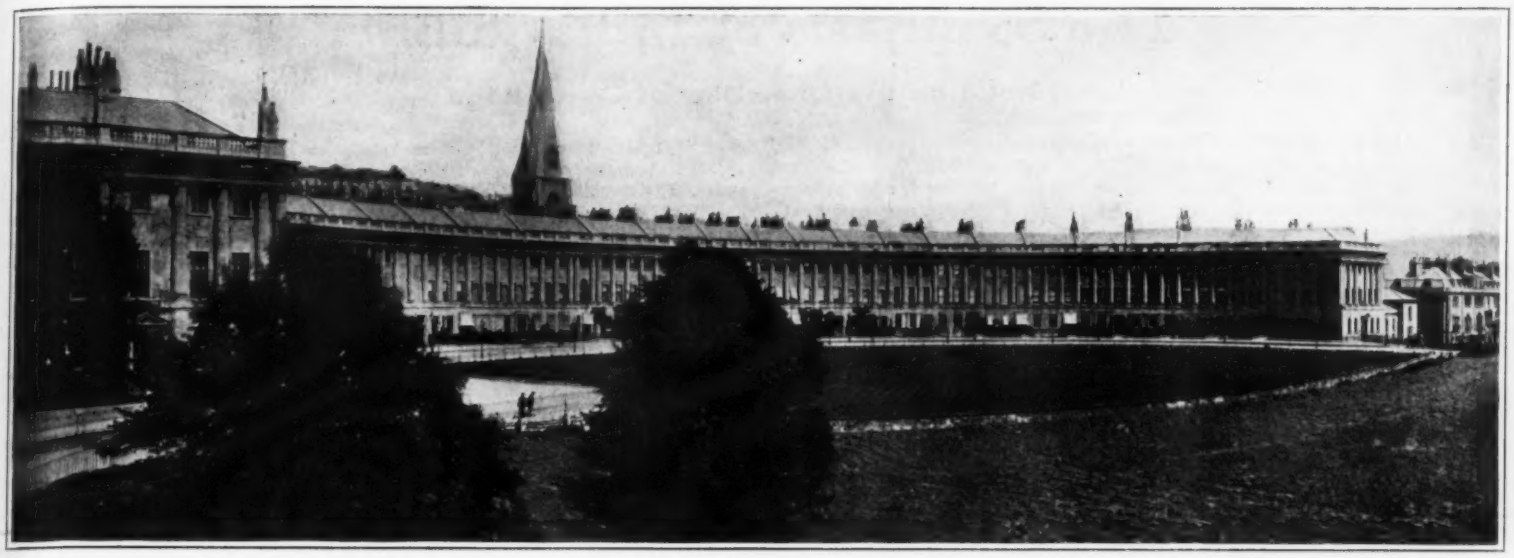
For nearly two thousand years, Bath has been the most famous health resort in the British Empire, and clear evidence exists to-day of the palatial baths and stately temples erected around the hot springs by the Romans. After the withdrawal of the latter from Britain, the baths were allowed to lapse into ruin, although they served to accommodate the Roman-British inhabitants until the city was destroyed by the Saxons, A.D. 577. The principal temple raised by the Romans was dedicated to Sul-Minerva and a large part of the original pediment as well as portions of the very handsome cornice and of one of the large columns can be seen in the Museum of Antiquities adjoining the present Roman baths. The tympanum of the pediment represented a shield upheld by two winged victories. The head on the shield is marked by an astonishing and almost barbaric vigor, its beautiful details still remain sharp and distinct, both in style and vehement character, stands quite alone among the sculptors of the Western Roman Empire. It may be added that Bath offers the additional attractions of a superb abbey, which dates back to the reign of Henry VII, A.D. 1499, and the very numerous mural tablets placed throughout the city are an indication of the celebrated people for whom it has proved an attraction. The names include those of Queen Charlotte, of Sir Thomas Lawrence, Tom Sheridan, Edmund Burke, Lord Chesterfield and Sir Walter Scott. It was from his house in New King Street that Herschel "swept the heavens," and there he first watched the planet Uranus drift into his ken.

During 1895, Sir William Ramsay discovered helium in the Bath waters and, a few years later, Lord Rayleigh made an investigation of the gases escaping from the King's Well and found that in ten thousand volumes of these gases there are twelve volumes of helium. Sir William also demonstrated that helium was present in some Continental mineral waters, but neither he nor any of his able assistants, chiefly from the French Academy of Medicine, were then able to satisfactorily explain how to the presence of helium could be credited the beneficial results that evidently resulted from taking such waters. The explanation was not forthcoming until 1903 when, as we have already stated, Sir William, in conjunction with Mr. Soddy, found that helium is one of the products of the change of radium and that its presence in the water is an indication that radium has been concerned in its production.

Many waters owe their curative properties to what may be called ordinary chemical ingredients, but the healing powers of the Bath Springs have been recognized since the days of the Romans, who built the famous bath that is one of the city's choicest historical remains, and according to Sir William, they owe most of their potency to the presence of radium. He found 0.1387 mille-

A Frascati Vase, Victoria Park.

Palladian Bridge, Prior Park.



The Royal Crescent, Bath.

grammes of radium in the water, also 1.73 millegrammes of niton (radium emanation) in the water and 33.65 milligrammes in the natural gas which is given off by the water. These figures appeared ridiculously small, but Sir William pointed out that the effect of radium was due to radiations of exceeding intensity and very generating. and, at present, though few observations have been made on the chemical change induced by the action of radium and its products, they knew that considerable changes were produced under the action of quantities of radium comparably with these amounts.

He estimated that no less than $30 worth of radium a day goes from the bathing establishments into the river Avon, but that they could not get it out, they could only use it. The curious but truly attractive yellow brown discoloration of all the glasses used in the pump room as well as of the bathroom tiles was not, as popularly supposed to be the case, due to the presence of the iron in the waters but to the influence of the radium. Sir William also stated that there was an extremely small amount of radium emanation in an enormous amount of water, but the water had taken up as much of the emanation as it possibly could, having regard to the solubility and the proportion of it. *While he was conducting his experiments he drank a glass of the water in the Pump Room with the other drinkers and on returning to his electroscope the instrument indicated unmistakably the presence of radium the moment he entered his temporary laboratory.*

As, to many of our readers, the chemistry of helium and radium is likely to be little known, we think best to quote a few explanations from the official report lately made by Sir William Ramsay: "Although an element, radium is unstable; that is to say, it is continually changing into another body, also 'elementary.' During this change, it parts with helium, each atom of radium furnishing one atom of helium. As atom after atom undergoes this change, miniature explosions take place, the effect being that atoms of helium are shot out with enormous velocity; they can be recognized by placing near the decomposing particle of radium a small screen or card covered with a crystalline deposit of sulphide of zinc. As each atom of helium impinges on the screen, a flash of light occurs. That this is the case was discovered by Sir William Crookes; and Prof. Rutherford, by counting the number of flashes—and by other means too intricate to be described here— has succeeded in demonstrating that each atom of radium omits one atom of helium. These atoms of helium in rapid motion have been termed α or alpha-rays. Their therapeutic effect is practically unknown; but they contain energy, or power of doing work, some twenty times greater than the other radiations, termed β (beta) and γ (gamma), which also accompany the decomposition of the products of radium.

"Having shot out its particle of helium, the atom of radium is no longer radium, but a gas, to which the name radium emanation' was given by Prof. Rutherford and, Mr. Soddy, but which, now that its properties and its atomic weight have been investigated, is better known as *niton*. The rate of change of radium into niton is a very slow one. In theory, a given weight of radium should take an infinite time to change completely into niton and helium, because, as the decay goes on, less and less of the radium is left, and that smaller quantity gives off proportionately less niton and helium. In order to avoid the infinitesimal, it has been agreed to speak of the 'half period of decay,' which is a perfectly definite interval of time. An ounce of radium, for example, after a period of 1,760 years, would have half changed into niton and helium, while half an ounce of radium would be left unchanged. After a further period of 1,760 years, half of the half ounce, i. e., a quarter of an ounce of radium would be left, the other quarter-ounce having produced niton and helium. This process would go on indefinitely, and it is thus evident why the 'half period of decay' has been chosen as a means of measurement.

"In collaboration, first with Mr. Soddy and made recently with my present assistant, Dr. Whytlaw-Gray, I have investigated this gas, niton. Like argon or helium, it is inert, that is, it forms no chemical compounds. In another sense, however, it is not inert, for, as shown by Rutherford and Soddy, it itself has only an ephemeral existence; in 3.86, or say 4 days, it has half changed. As the activity of these substances depends upon their rate of change, niton is a much more potent agent, weight for weight, than radium; indeed, the potency of radium may be ascribed to the extent of at least seventy-five per cent to the action of its product, niton.

"It is the beta-rays which have been chiefly used for therapeutic purposes. While alpha-rays, that is atoms of helium, like other gases, can be confined in glass or metal vessels, beta-rays pass through; the amount passing naturally depends on the thickness of the walls of the vessel. The alpha-rays, for example, given off from niton confined in a glass tube do not pass through the glass; the beta-rays, due to the products of change of the niton do pass through; and, by interposing metal screens of foil of different thinknesses, a greater or smaller quantity may be allowed to impinge upon the patient's skin. Experiments on different animals, which I have made in conjunction with Dr Stevenson in the Medical School at University College, show that the niton is got rid of chiefly by the lungs in about three hours. After twelve hours all traces have disappeared. It may be that when a patient takes a bath, the skin absorbs some niton; and some undoubtedly enters the lungs for it is continually being given off from the surface of the hot water.

"This skin absorption might be greatly increased in the following way: Taking for granted you have an installation for giving electric baths, the current dealt with is an alternating one; it may and undoubtedly does produce electric stimulus; but the fact of the rapid reversal of the current prevents any concentration of niton on the skin. Now, niton in disintegrating is continuously discharging electrons, or, in the older phraseology, losing negative electricity, and becoming positively charged. It follows that it will be attracted by a negatively charged body. If the patient in the electric bath were connected with the negative pole of a battery giving, say, one hundred volts potential, or even more, and the other electrode were placed in the water, of course not in contact with the bather, the niton would rapidly reach the skin. It is, indeed, not unlikely that it would enter the system by, so called, "ionization," and in this way a considerable dose might be given. The apparatus would require the substitution of a continuous for an alternating current, and suitable measuring instruments, but this would entail no great expense. Naturally, any experimenting on these lines would require to be made with caution; I do not know of any attempts in such a direction. I suppose that such a bath as is generally in use may contain about a cubic meter of water; if that be so, then the amount of niton in the bath would be excessively small; and even if it were all absorbed, it could not, judging by the results of the experiments made on animals, prove a dangerous dose."

Sir William Ramsay is at present engaged in an exhaustive analysis of the residue from the waters of the King's Well and we may soon know the results.

The King's Well.

The Great Roman Bath.

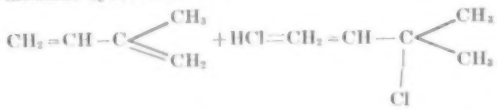
The Synthesis of India-Rubber*

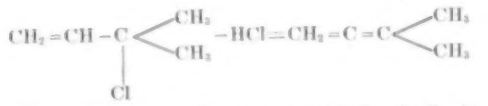
Notes on the Chemistry of Caoutchouc

THE problem of synthesizing India rubber appears to be identical with that of the synthesis of isopren and its polymerization into India rubber. Under the circumstances, the constitution of isopren becomes of paramount importance and may be advantageously discussed at some length.

Tilden[1] already concluded that isopren had the constitutional formula of $CH_2=C(CH_3)—CH=CH_2$, giving it the name of beta-methylerotonylene. But he did not support his theory by experiments, and it was Gadziatzky[2] who carried out the first researches which partially confirmed the Tilden formula. This author prepared from the monochlorhydrate of isopren a tertiary alcohol, dimethylvinylcarbinol,

Subsequently[3] he found that isopren is converted into an isomeric dimethyl-allene if it is heated with weak alcoholic hydrochloric acid.





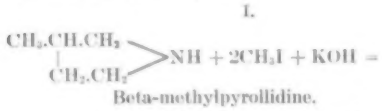
These experiments, however, furnished only liquids which were liable to decomposition on distillation, and altogether did not possess sufficiently definite properties.

Mokiewsky[4] produced the first crystalline body by the action of hypochlorous acid upon isopren.

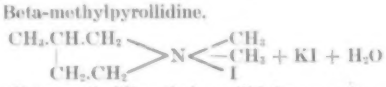
Ipatiev and Hittorf[5] experimented with dihydrobromides of the formula $C_5H_{10}Br_2$ and contributed largely to the experimental proof of the constitution of isopren, which, however, was finally supplied by Euler[6] who produced beta-methyldivinyl synthetically and showed it to be identical with isopren.

Basing his experiments on the reaction published by Ciamician and Magnaghi[7] who prepared divinyl from dimethylpyrollidyl-ammonium iodide on treatment with caustic potash, he transformed beta-methylpyrollidine into beta-methyldivinyl as follows:

I.

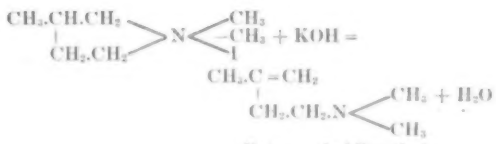


Beta-methylpyrollidine.



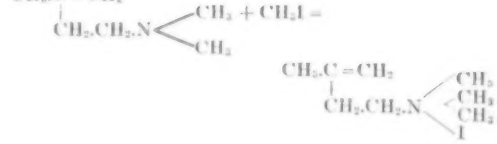
Beta-methyldimethylpyrollidyl-ammonium iodide.

II.



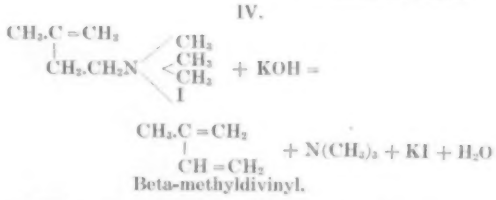
Beta-methyldimethyl-pyrollidine.

III.



Beta-methyltrimethylpyrollidyl-ammonium iodide.

IV.



Beta-methyldivinyl.

* Partially reproduced from *The Journal of Industrial and Engineering Chemistry.*

[1] *Bull. soc. chim.*, [2] 47, 168.
[2] *Chem. News*, 46, 129.
[3] *Jour. Russ. Chem. Ges.*, 20, 1, 706.
[4] *Jour. Russ. Chem. Ges.*, 27, 516.
[5] *Jour. prakt. Chem.*, [2] 55.
[6] *Ibid.*, [2] 57, 131.
[7] *Ber.*, 18, 2080.

The beta-methyldivinyl which is furnished by these reactions is identical with isopren and the steps of the process furnish absolute proof of the constitution of isopren, namely $CH_2=C.CH_3—CH=CH_2$.

As stated above, the main problem with which we have to deal in the synthesis of India rubber is the economical production and the polymerization of isopren. If, however, the constitution of isopren as a diolefin with two double valencies is considered, another line of research suggests itself as a matter of course. Undoubtedly the polymerization to India rubber takes place at the double links of the chain $C=C—C=C$, and if such is the case all hydrocarbons with such double links ought to furnish India rubbers on polymerization. If this proves to be correct we ought to be able to produce by synthesis not only the ordinary India rubber which is a methyl derivative, but also the methyl-free mother substance of India rubber and all kinds of "alkyl" and "aryl" India rubbers from homologues, etc., of isopren.

Accordingly 1,3-butadien, which is the simplest member of this series, $CH_2=CH—CH=CH_2$, ought to polymerize into the mother substance of India rubber or "Nor-caoutchouc," a name proposed by Harries because the term "caoutchouc" itself has already been appropriated for the methyl derivative furnished by nature; therefore the methyl-free mother substance to be synthesized, should bear the prefix "Nor" attached to the name under which the natural product is known.

In other words, a "Nor" substance is the synthetic, methyl-free, simplest form or mother substance of a series of bodies, the methyl derivative of which occurs in nature.

Consequently higher homologues of isopren, for example, the 2,3-dimethyl-1,3-butadien,

$$CH_2=C(CH_3)—C(CH_3)=CH_2,$$

should give a methyl India rubber and so on. What an endless vista of homologous and analogous rubbers opens itself before the eyes of the imaginative research chemist!

How much of these speculations and theories, or whether anything at all, has become a source of commercial success does not appear from the literature. But the Patent Offices are already reaping a huge harvest from the real and imaginary inventions in this branch of synthetical chemistry.

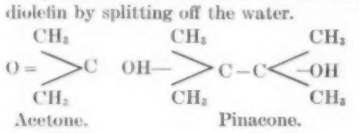
Any number of patents have been applied for and many have been already published especially by the English Patent Office. Of what value they are is beyond our judgment!

We shall, however, append here a few applications as we found them recorded in a recent article in the new journal, *Kunststoffe*, 1911, p. 65.

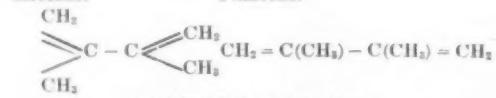
In a German patent application of November 29th, 1909 (British patent 15,254, June 25th, 1910), the Elberfelder Farbenfabriken describes the production of "Nor" caoutchouc by heating erythren (butadien) with or without the addition of reagents which facilitate polymerization. Among the various directions, we find the following: Eyrthren dissolved in benzol is heated for ten hours to 150 degrees, or erythrene condensed at low temperature (ether-carbonic acid) is kept in an autoclave at 90 to 100 degrees for four days. In both cases the solvents, unreacted upon starting material, and by-products are distilled off (*in vacuo* or by steam) and caoutchouc-like masses resembling India rubber remain as a residue.

French patent of the Badische Anilin- und Soda-Fabrik 417,170, June 15th, 1910, describes the polymerization as follows: Isopren is heated for twenty hours about 120 degrees, and erythren for ten hours to 150 deg. Cent., or isopren with an addition of 10 per cent of its weight of concentrated alcoholic caustic soda lye is heated to 100 degrees for a sufficiently long time; after distilling off unreacted-upon isopren, caoutchouc is either dissolved in benzol and precipitated with alcohol or kneaded into a compact mass.

British patent 14,281 of 1910 to the Badische Anilin- und Soda-Fabrik describes the polymerization of 2,3-dimethyl-1,3-butadien, $CH_2=C(CH_3)—C(CH_3)=CH_2$. This hydrocarbon had already been investigated by Kondakow.[8] It is obtained from acetone by reduction; the pinacon which is first formed is converted into the diolefin by splitting off the water.



Acetone. Pinacone.



2,3-Dimethyl-1,3-butadien.

The Badische Anilin- und Soda-Fabrik states that if 2,3-dimethyl-1,3-butadien be heated, either alone, or with an indifferent agent, such, for instance, as water, or a solution of common salt, or alcohol, or ether, or benzene, a product resembling caoutchouc is obtained in better yield and in purer form than is obtained according to the method described by Kondakow, and moreover, the product of the present invention differs from that of Kondakow in being insoluble in alcohol. They can also obtain a product with similar properties by carrying out the heating in the presence of an aqueous solution or suspension of a base or of a salt which acts as a base, and in this case a small proportion of alcohol may be present without materially affecting the course of the reaction, but if a large proportion of alcohol be present the desired results are not obtained. As instances of substances which can be used in carrying out this invention, the alkalies, the hydroxides of the alkaline earth metals, and salts of an alkaline reaction (such, for instance, as the alkaline carbonates) are mentioned.

The following are given as examples of how this invention can be carried into practical effect, but the invention is not confined to these examples. The parts are by weight.

EXAMPLE 1.

Heat together equal quantities of 2,3-dimethyl-1,3-butadien and water in an autoclave for sixty hours at about 100 deg. Cent. On distilling off any unaltered initial material in a current of steam, a white elastic substance, possessing the typical properties of caoutchouc, is obtained. It is soluble in benzene and is precipitated, in an unaltered condition, from the benzene solution by means of alcohol.

Instead of water in this example, a 10 per cent solution of common salt or a solution of any other suitable indifferent salt can be employed and, if desired, a higher pressure can be obtained by passing an indifferent gas (such, for instance, as nitrogen) under pressure into the autoclave.

EXAMPLE 2.

Heat 2,3-dimethyl-1,3-butadien in an autoclave for sixty hours at from 90 to 100 deg. Cent. and work up the product as described in the foregoing example 1.

2,3-Dimethyl-1,3-butadien can also be caused to undergo polymerization by heating it with, for instance, equal quantities of other alcohol or benzene.

EXAMPLE 3.

Heat together equal parts of 2,3-dimethyl-1,3-butadien and caustic soda of 14 per cent strength, for eighty hours in an autoclave at 100 deg. Cent. On distilling off any unchanged initial material with steam, a substance resembling caoutchouc is obtained.

In a similar manner, either stronger or more dilute caustic alkali can be employed, or aqueous alcoholic alkali containing say 20 per cent of alcohol, but preferably less, can be used.

Alkali carbonate, or ammonia, or an earth alkaline hydroxide can be used instead of the caustic alkali.

The India rubber which is thus produced might be called methyl caoutchouc. Thus we already know the series:

'Nor-caoutchouc,' polymerized erythren. 'Caoutchouc,' polymerized isopren. 'Methylcaoutchouc,' polymerized dimethylbutadien.

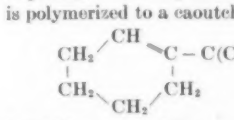
The most interesting of all descriptions yet published is a new German patent application (F. 29898, Kl 39 *b*) of the Elberfelder Farbenfabriken (postscript of article in *Kunststoffe*) which directs polymerization under the following conditions: Heating in an autoclave to 150 degrees for twenty-four hours, heating twelve hours to 200 degrees, eight days to 90 or 100 degrees, heating to 35 degrees for three months in a closed vessel. As agent of polymerization formic acid and creosote may be employed. Besides the diolefins already mentioned, the following hydrocarbons are polymerized into caoutchouc.

$(CH_3)CH=CH—CH=CH_2$ furnishes an isomer of natural caoutchouc.

$(CH_3)_2C=CH—CH=CH_2$ furnishes an isomer of the above methylcaoutchouc.

$(CH_3)_2C=CH—CH=C(CH_3)_2$ furnishes a tri-methyl-caoutchouc.

And finally—which is a reaction of the very greatest importance—the hydrocarbon, isopropenylcyclohexen, is polymerized to a caoutchouc,



furnishing a cyclohexen caoutchouc.

We also wish to mention Prof. Harries' method of polymerization of isopren. The substance is heated with glacial acetic acid in a closed tube to a little above 100 deg. Cent. He finds that isopren from caoutchouc is not as easily polymerized as synthetic isopren and states that his conditions of reaction must be strictly

[8] *Jour. prakt. Chemie*, Neue Folge, 62, 175-176.

adhered to, otherwise no isopren is formed, but instead a resinous, oily mass.

Harries identified his product as synthetic caoutchoue as follows: A sample was ozonized in a chloroform solution, the resulting ozonide was split up by water and half of the theoretical quantity of levulin-aldehyde recovered. On treatment with nitrous acid, the nitrosite decomposing at 167 deg. Cent., was easily and quantitatively obtained, bromide gave the tetra-bromide. He claims that the synthetic caoutchoue is as tough and elastic as the natural product; it is of light brown to whitish color.

As a curiosity we might here mention British patent 15,299 of 1909, with the following claim:

The treatment of isoprene or its homologues or material containing them, consisting in subjecting the isoprene or the like to the action of anaerobic bacilli obtained from natural rubber or latex or from other sources or enzymes obtained with such bacilli.

All the publications quoted thus far refer to the polymerization of only such diolefins as are already known in chemical literature, and the preparation of which is generally extremely difficult and exceedingly expensive. There seems no doubt that cheap methods for their production will be discovered before long and perhaps have already been found. The patent literature on this point is very scant and we are able to record only the following specifications:

In English patent 27,908 of 1909 Woltereck describes the production of isopren by conducting the vapors of turpentine over iron at temperatures of 550 to 600 deg. Cent.

Heinemann, British patent 21,772 of 1907, French patent 394,795, Belgium patent 210,979, first forms 1,3-butadien from acetylen and ethylen at dark red heat.

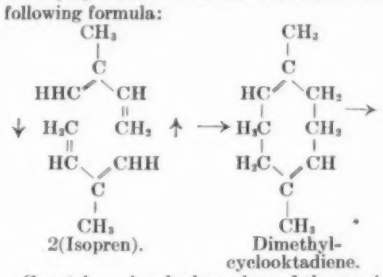
$$CH \equiv CH + CH_2 = CH_2 = CH_2 = CH - CH = CH_2.$$

Then he allows chlormethyl to act on the butadien,

$$CH_2 = CH - CH = CH_2 + CH_3Cl = CH_2 = C(CH_3) - CH = CH_2.$$

It is interesting to note that in spite of Harries' annihilating criticism of Heinemann's process, this inventor has advertised in the chemical journals that he is ready to furnish isopren in any quantity.

It will perhaps prove of interest to refer to the most modern theory on the polymerization of isopren and the constitution of caoutchoue. Harries claims that isopren first furnishes dimethylcyclooktadiene, which then polymerizes to India rubber, as shown by the following formula:



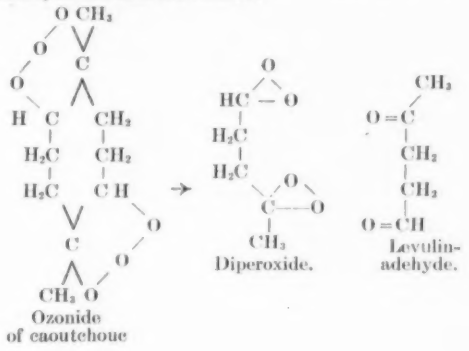
Caoutchoue is a hydrocarbon of the empirical formula $C_{10}H_{16}$, it is optically inactive and therefore has no asymmetric carbon in its molecule. On bromination it absorbs 4 atoms of bromine, therefore it contains 2 ethylene groups. Treated with ozone in chloroform solution, it absorbs 2 molecules of ozone. Since this ozonide is readily soluble, its molecular weight can be easily ascertained, it is $C_{10}H_{16}O_6$. This formula shows that the addition of ozone is preceded by a depolymerization of the large molecule. On boiling this ozonide with water, it is decomposed into levulinaldehyde, levulinic acid and a crystallized substance which Harries considers to be levulin-aldehyde diperoxide.

$C_{10}H_{16}O_3 = CH_3—CO—CH_2—CH_2—CHO$, levulin-aldehyde.

$CH_3—CO—CH_2—CH_2—COOH$, levulinic acid.

$CH_3—CO_2—CH_2—CH_2—CHO.O$, levulin-aldehyde-diperoxide.

This decomposition proves that the ozonide of caoutchoue contains an 8-carbon ring, because ozone enters the molecule at the ethylen groups and on splitting the molecule, the nucleus is broken at the place where the ozone was added and oxygen-containing products, aldehyde and acid are formed:



Immunity and Its Mechanism

The Battle Between the White Blood Corpuscles and Invading Bacteria

THE whole question of immunity, native or acquired, to poisons and to the toxins of disease is of such vast import to the race as well as to the individual that a knowledge of its nature and mechanism cannot be too widely diffused.

We note in *Le Mois* an article by the scientific writer Acloque on this topic, in which he compiles and summarizes in his usual lucid and agreeable manner the available knowledge of the subject.

We present excerpts from the article as follows:

There are two sorts of immunity, the one is natural and spontaneous (and nearly always specific), the other is acquired (and consequently individual). The fowl is resistant to anthrax and to tetanus, which readily attack the human being; the Algerian sheep is resistent to anthrax, to which on the other hand European sheep are very susceptible; the buffalo does not contract tuberculosis, to which the beef is very sensitive.

These are examples of spontaneous and specific immunity. This natural resistance to a given microbe may be a property, moreover, not merely of a species, but of the age of the individual, adults, for instance, being resistant, while their young are sensitive.

Also, it may be constant, i. e., it may manifest a persistence in spite of variation in the conditions of inoculation, such as excessive virulence of the germ, or vital weakness of the receptive organism.

Man offers this fixed immunity to cowpox, and cattle to glanders.

On the other hand, the resistance may be only relative, and may disappear before intense activity of the bacteria, or if the individual is placed at the moment of inoculation in circumstances which diminish his resisting powers. The guinea-pig, for example, is normally immune to the streptococcus; but a very virulent germ of this kind introduced into the peritoneum will induce peritonitis.

In the same way, the fowl, resistant to anthrax at the normal temperature of its body, becomes sensitive to it, if its temperature be lowered by placing its feet in cold water. The frog, ordinarily immune to the bacillus of human tuberculosis, is attacked by it when kept in a receptacle where the temperature is 38 deg. Cent.

Spontaneous immunity exists not only with regard to microbes, but also to the toxins they secrete. These toxins are poisons secreted by the bacteria and are the products of their nutrition at the expense of the medium in which they live. The scorpion and the cricket support with impunity large doses of tetanus toxin; the frog, lizard, and turtle are perfectly resistant to this toxin.

Such immunity to microbe toxins may be compared to that which some animals present to poisonous alkaloids; the fowl is non-sensitive to morphine, and the rabbit to atropine.

Acquired immunity is that shown to a given microbe by an organism not ordinarily resistant to it, following a physiological change produced in the immunized organism.

It has long been known that after the spontaneous cure of certain infectious diseases the patient is resistant for a varying length of time to a new attack by the same disease. In man an almost absolute immunity is established after typhoid fever, variola, mumps, whooping cough, measles and scarlet fever.

Other bacterial diseases, such as cholera, diphtheria, tetanus, do not confer immunity, or only for a very short time; and in some, as erysipelas and pneumonia, a first attack seems to augment the receptivity of the individual and prepare the way for an inevitable recurrence.

In exceptional cases immunity against a microbe may be acquired by inoculation with a microbe of a different sort. Thus the simultaneous introduction into the organism of the *bacillus anthracis* (the agent of anthrax) and of the pyocyanic bacillus (which produces the "blue suppuration") vaccinates against anthrax. But as a rule resistance follows an experimental inoculation with the same virus, made under conditions which reduce the danger to a minimum. This preventive inoculation, whose aim is to produce the disease in an attenuated and benignant form, is performed in different ways. Sometimes microbes of normal virulence are employed, but in very minute doses. Sometimes the method of entry is modified: the virus of anthrax produces death if introduced under the skin, and becomes a vaccine when injected into the circulation of the blood. Sometimes microbes are used whose virulence has been artificially attenuated, either by heat, by antiseptics, or by the aging of the culture.

This last method, which is used against anthrax and hydrophobia, we owe to Pasteur himself. It is often modified in practice by injecting microbes of progressively augmenting virulence, after a primary inoculation with those of attenuated strength. Sometimes this first step is taken with microbes which have been killed by heat. This mode is usually employed for microbes whose toxin is not soluble and diffusible.

In the case of a soluble toxin it is preferable to inject this toxin filtered and freed of the secreting bacteria.

Immunity is conferred by the inoculation with a living virus only against this virus, and not against its toxin. But inoculation with a toxin immunizes both against the toxin and the microbe.

This property of living organisms which enables them to resist invasion by foreign living cells—microbes, ferments, or blood corpuscles is—known as phagocytosis.

The leucocytes, or white blood corpuscles, which are formed principally in the spleen, the lymphatic ganglions, and the marrow of the bones, strongly resemble rudimentary protozoa of the amoeba group; like these they are capable of extending in every direction prolongations of their protoplasm known as pseudopodia; also like the amoeba they surround and digest microorganisms with which they come in contact.

Accumulated at special points in the body, and also prone to cling by their pseudopods to the walls of the blood-vessels, they are vigilant sentinels, whose office is to repel intruders.

When a pathogenic bacterium enters an organism suitable for its nutrition, it rapidly proliferates, forming a colony which secretes a specific toxin. This mingles with the fluids of the body, and the leucocytes, at first repulsed by the sudden change in their *milieu*, rally in large numbers about the point of attack. The battle is on between bacteria and leucocytes, the latter seeking to surround and digest the former; at the same time they multiply vigorously in the endangered organism, whose fate depends on the issue of the combat.

If the bacteria win, the result is death. If the leucocytes, there is not only a cure, but also immunization in all cases where the nature of the microbe provokes this physiologic modification. The apparently capricious progress of epidemics is due to a variation in this phagocytosis, the leucocytes of some individuals being more energetic than those of others.

Phagocytosis also explains, at least partially, the acquiring of immunity. If we inoculate with a given virus an animal which has recovered from a first attack of the same virus, the leucocytes, instead of fleeing at first from the enemy, respond instantly by rushing to the breach. Furthermore, the phagocytosis is much more intense than in a non-vaccinated animal. Phagocytosis is in brief nothing but an intercellular digestion of bacteria. It is made possible by special substances known as philocytases elaborated by the leucocytes to permit the destructive intervention of the digestive ferments of these leucocytes, ferments constituting the cytases.

The most recent investigations have shown in the blood of vaccinated animals the presence of divers properties all having as their object the prompt destruction of the virus against which the first inoculation has created immunization.

The serum of the guinea-pig, e. g., which in a normal state exerts no action on the cholera vibrio, shows itself bactericidal to this vibrio when taken from a vaccinated individual. If we inoculate the peritoneum of a guinea-pig thus vaccinated with cholera vibrios, these will lose their mobility and in a short time be transformed into granules. The serum of a guinea-pig vaccinated with cholera serum will kill cholera vibrios when mixed with them even outside the animal's body.

Beside this bactericidal property, which is not constant for all cases of immunization, there may be observed in the serum of vaccinated animals (varying according to the species, the experiment, and the nature of the virus) substances which show hostility to the microbes, either by agglutinating them, by precipitating them, or by exalting the digestive power and aggressive energy of the leucocytes. These, which are not thoroughly understood, are known as agglutinants, precipitants, or stimulants.

It is interesting to note that immunization consists, in sum, merely of the development in the serum of the vaccinated animal of bactericidal properties existing in the blood of other species spontaneously immune.

The serum of the rabbit and the horse are highly bactericidal to the cholera vibrio and to the Eberth bacillus (which is the agent of typhoid fever).

The serum of the white rat, an animal spontaneously resistant to anthrax, transforms the anthrax bacteria into granules and completely dissolves them in 24 hours. The serum of the horse agglutinates the cholera vibrio, and in a certain proportion the Eberth bacillus, the coli bacillus and that of tetanus; human serum notably agglutinates anthrax bacteria.

Among the various theories offered in explanation of phagocytosis we may mention that which is most widely received. The foreign element introduced into the organism (a toxin, microbe, or blood corpuscle) is the *antigen*. The protective agent the organism opposes to it is the *antibody*. This is, as the case may be, an agglutinant, a precipitant, or a lysine, i. e., a substance adapted to disintegrate and dissolve the foreign toxic element. If the organism triumphs over the invaders the *antibody* elaborated in this perilous crisis remains in the serum, and thus confers immunity against the same virus.

The lysine may be considered as composed of two substances mutually aiding in the destruction of the *antigen*. The one, existing in all normal serum and destroyed by a temperature of 55 deg. Cent., has been variously called cytase, alexine, or "the complement;" the other, specific, existing only in the blood of vaccinated animals and having no effect except against the virus for which the vaccination produced it, is the "fixator" or "sensitizer." In the destruction of the invader (bacteriolysis, cytolysis, hemolysis), it is the alexine which occasions the disintegration, but only on condition that the fixator has previously rendered the foreign element sensitive to its action.

The immunity acquired by inoculating with virus or toxin may be communicated passively to a non-vaccinated animal by the injection of a suitable dose of serum from a vaccinated animal. This is the principle of serotherapy, that precious resource of modern therapeutics against bacterial infections. Serotherapy is above all *preventive*, and almost equal to a real vaccination; it is not curative except in certain rare cases, of which diphtheria is an example.

An important fact, and one pregnant with consequences, is that the immunity acquired by an individual is transmissible by heredity. If we consider that in an epidemic the individuals that succumb are those whose leucocytes are inferior, we conclude that the survivors and their descendants constitute by natural selection a race endowed with energetic powers of phagocytosis. Thus is explained the resistance of the Algerian sheep to anthrax, and that of the inhabitants of large cities to typhoid fever.

Air Washers and Humidifiers for Public Buildings, Factories and Mines

IT has of late become a fairly widespread practice to purify the air fed to large public buildings, such as schools, hospitals and so forth, by passing it through a suitable washing or scrubbing plant. As an example for the need for such purification may be mentioned the case of Public School No. 6 of Brooklyn, N. Y., where the dirt collected in the course of one week in the air purifiers filled five pails. This school is one of the new type of the fine school buildings which are being erected in the city of New York. It is located near the Borough Hall in Brooklyn, where the air is no dirtier than any other part of Brooklyn or New York.

There could be no better illustration presented to show the necessity of effectual air cleaning or the value and efficency of the latest air washer and humidifier equipment now being extensively introduced in libraries and other public buildings as well as factories and cotton, silk and other mills.

Considered from a hygienic or economical standpoint, one can not but be impressed with the results obtained. It certainly is anything but beneficial to breathe into the lungs, air with all kinds of dirt and dust, carrying various diseases. The economy of labor for cleaning the building and the great saving to the decorations and contents of the building by excluding this great amount of dirt may be readily seen. The same apparatus moistens the air used for ventilation in winter, thus adding much to comfort and making the conditions more healthful. Nature provides moisture in the air, in quantities ranging from 40 to 70 degrees of saturation. But in heated buildings the heating apparatus dries out the air, lowering the relative humidity far below that of the outside atmosphere.

Dry air parches the delicate skin of the nose and throat and causes catarrh and other kindred diseases. All this is prevented by the air washer and humidifier, as it moistens the air before the latter enters the room, while during the warmer months the air can be cooled several degrees in passing through the air washer. The accompanying illustrations Figs. 1, 2 and 3 show a complete electrically operated air washing plant and the design of one type of spray nozzle and its application in humidifying the air.

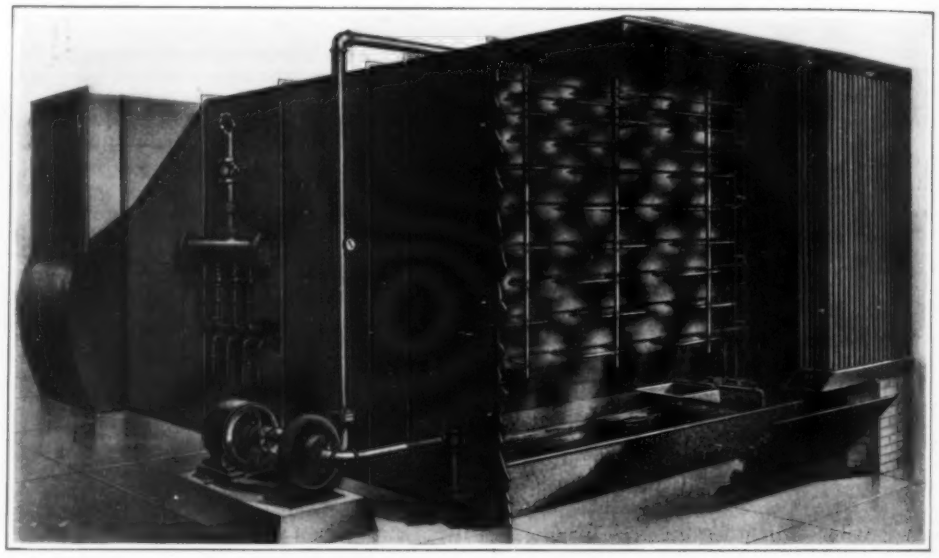


Fig. 1.—General View of Air-Washing Plant.

The positive control of atmospheric conditions within inclosures is an art of comparatively recent development. The conditions for which regulation is sought are cleanliness, temperature and moisture or humidity, and the demand for the mechanical regulation of these features has developed rapidly within the last decade.

There is no question but that the hygienic benefits of a uniform and proper degree of humidity, temperature and cleanliness combined with ventilation is now beginning to receive the serious consideration which its importance demands. The irritation caused by breathing excessively dirty or dust-laden air, even though otherwise pure, is responsible for a large class of diseases of the respiratory organs. Moreover the germs of contagious diseases are said to be conveyed entirely by attachment to dust particles floating in the air, making dusty air a double menace to health.

Apart from the hygienic aspect of the process, requirements in many manufactories make air-conditioning highly advantageous or even imperative. This is true in the manufacture of textiles, in the manufacture of photographic films, of all gelatine products, and in the manufacture of various confections. An exactly controlled humidity of the air is necessary also in lithograph printing, in the malting of grain, in cold storage of many products, and is of highest importance in the smelting of iron ore.

In the mining industry without doubt it will be a short time only before an air-conditioning installation will be required by law in every coal mine throughout the country as the only sure and practical means of preventing mine explosions due to dryness of the air in the mines in the winter months.

There are various types of apparatus in use, but all air purifiers are either of the dry air filter type or of the moist washer type. The dry air filter has its legitimate field and is applicable wherever air is to be cleaned without moisture, and when properly designed it can be made a fairly efficient means of removing solid impurities.

In some cases no adequate means of cleaning is provided, and the screen becomes only a hindrance and a detriment to the ventilating system. To make this form effective some mechanical means of continuous or intermittent cleaning which will not interfere with the operation of the plant is essential and cloth closely woven or else several thicknesses of coarse mesh is necessary to obtain adequate cleaning, as the ordinary one-thickness cheese cloth will not answer. Sufficient filtering area is also essential to avoid excessive resistance to the passage of air.

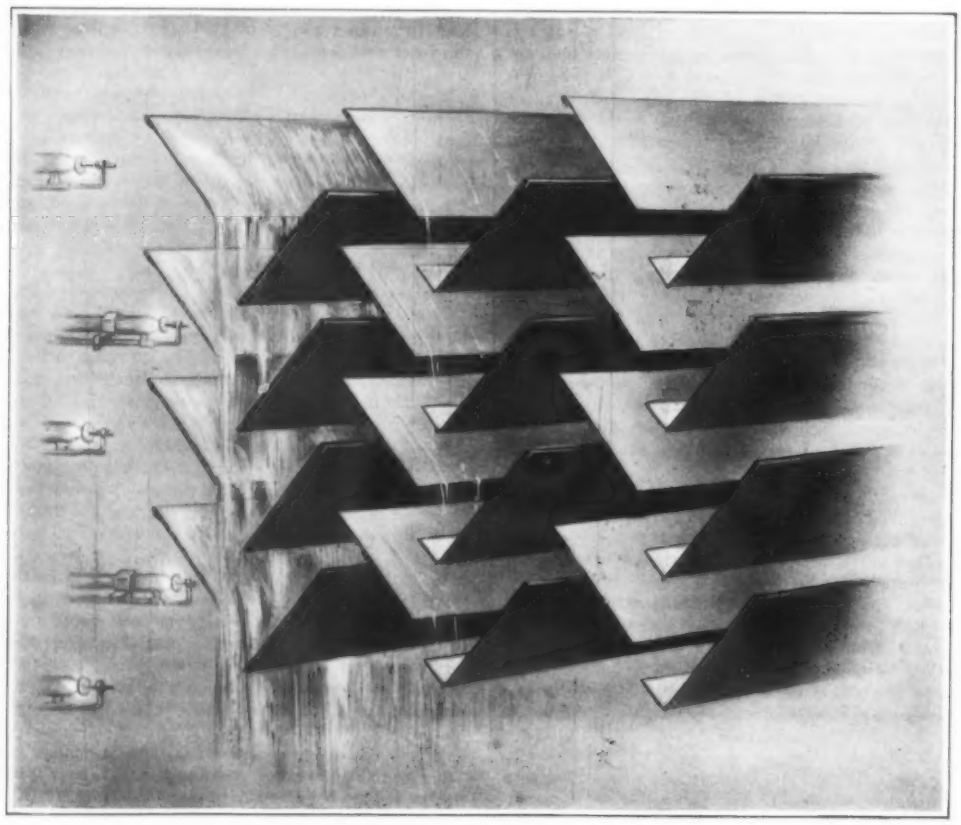


Fig. 2.—The Baffles and Sprays.

Many engineers hold that the air washer has a number of advantages over the dry filter for most purposes. The usual form of washer depends for its action upon bringing the air into more or less intimate contact with water first in the form of a spray, and secondly in the form of a film on metal plates.

The advantages of the air washer over the dry filter are: that it is compact, it is practically self-cleaning, it not only removes solid matter efficiently but also extracts a large proportion of the soluble gases such as sulphur dioxide, carbon dioxide and evil-smelling vapors.

That these odors may be removed most completely has been demonstrated by installation in the vicinity of rendering works and packing houses where the air outside would be nauseating while in the buildings ventilated with washed air the odor could not be detected. In such locations, of course, the water must be continuously changed, otherwise it would become saturated and ill smelling.

In the first attempts to wash air a coke screen was used, over which running water was allowed to trickle. But this device proved unsatisfactory because it either occupied too much space or else offered too great a resistance. It also very quickly became foul with impurities and therefore formed a source of contamination. The present types of air washers have a spray system for supplying the water, usually requiring some form of nozzle and a centrifugal pump for supplying the water under head. There is a washing chamber provided in which the air is brought in contact with the water spray and an eliminator for the removal of the water from the air.

There is also employed a settling tank for holding the supply of water which is re-circulated and a strainer or filter for preventing the coarser dirt from entering the spray system.

Most of the air washers differ from one another largely in construction of the spray nozzles, and in the design of the eliminator, the two most essential elements. The "Acme" washer is designed with an eliminator composed of four rows of separate vertical plates or baffles. The baffle plates are about six inches wide and spaced about six inches apart in the row. Each baffle is provided with a projection or lip for retaining the water which impinges on the plate. The baffles in one row are staggered with reference to, and placed at right angles to the baffles in the next row. The nozzles discharge the water in the form of a vertical sheet which is afterward broken up into drops by the impact of the air current and the nozzles are cleaned by a hand-operated flushing device.

The McCreary washer is distinguished from other types by its "S" shape spray chamber which forces the air to pass through three sets of sprays, while the Webster washer employs horizontal baffle plates instead of vertical. It also differs from all others in using a single spray head at the top of the washer which discharges downward, giving a "spray and rain effect."

In the construction of the Kinealy washer there are horizontal baffles in the eliminator similar to those of the Webster, but nozzles similar in type to those in the Acme are used, provided with an automatic cleaning device. In the design of the Carrier washer and humidifier the spray nozzles used are arranged so that the water enters a small circular chamber tangentially, which gives it a whirling or centrifugal action. The outlet or discharge opening is in the axis of rotation, placed at the end of a conical approach. This greatly increases the whirling speed of the water at the point of discharge and delivers it as a minutely divided or atomized spray that offers an enormous surface for evaporation and cleaning.

The eliminators are usually built of galvanized iron, but may be copper, and are placed in vertical position across the discharge end of the spray chamber. Each eliminator plate is made of a single sheet so stamped as to form several corrugations, three of which have projecting lips. The plates are held together with galvanized angles at the top and bottom and at intervals throughout the height, so as to keep them evenly spaced. All the rivets and bolts used in the construction are galvanized.

The action of the eliminator is two-fold. The first portion of the eliminator is designed especially for washing effect and is not provided with flutters so that the water is permitted to pass from one connection to the next without obstruction. The second portion is provided with projecting lips to form gutters which complete the elimination of moisture. The plates are spaced only slightly over an inch apart thus sub-dividing the air very completely and affording an enormous washing surface.

The free moisture together with moisture-laden dirt is removed in the eliminator by the combined action of centrifugal force and impact. A distinguishing feature employed in this washer is the row of flushing sprays placed at the top of the eliminators which continually floods the whole of the eliminator surface. This greatly increases the effectiveness of the washing surface and prevents the plates from becoming foul.

All forms of air washers do a certain amount of humidifying, depending on the degree of contact of air with water, but it is clear that none of them as ordinarily used as washers will give a complete saturation.

As regards the theory of humidifying, it is a well known principle in physics that the vapor pressure or tension of a confined liquid increases with its temperature according to a definite law. It is also known that a volatile liquid will vaporize in air at any temperature and atmospheric pressure, and that the maximum density of this gaseous product will depend entirely on the temperature regardless of the presence of other gases or vapors.

In passing from the liquid to the gaseous state a great amount of heat is absorbed. In general the heat of vaporization is greater the lower the temperature. The density or moisture-holding capacity increases at a far more rapid rate than the temperature. The actual weight of water vapor per cubic foot is termed the absolute humidity and the saturation temperature corresponding to this density is called the dew point.

As saturated water vapor either alone or in admixture with air is raised in temperature without additional evaporation of water, it becomes superheated. The degree of superheat determines what is known as the relative humidity of the air. The relative humidity is expressed as a ratio of actual vapor density to the density of saturated vapor at the same temperature, i. e., it is the ratio of what air does hold to what it could hold at the same temperature.

When a superheated vapor is brought into contact with the liquid it immediately loses its superheat, partly through evaporation and partly by increase of vapor pressure. In dry air, which is merely a mixture of air and superheated water vapor, the heat of vaporization is taken from the air from the superheated vapor and from the water itself, when the saturation is completed the air and the water will be at the same temperature, which

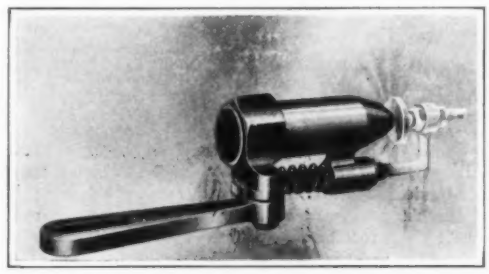


Fig. 3.—Spray Nozzle for use in humidifying the air.

is obviously between the initial temperature and the dew point.

Water exposed to dry air and unaffected by any source of heat will remain at a constant temperature as it evaporates, which is somewhat below the temperature of the air. This temperature is the same as that which the air will attain where it becomes saturated—this is known as the wet bulb temperature, observed by covering a thermometer bulb with a wet cloth.

The difference between this wet bulb temperature and the actual air temperature is called the wet-bulb depression. This is a direct measure of the moisture-absorbing capacity of the air. For each degree depression of the wet-bulb temperature a pound of air has capacity to absorb 1.4 grains moisture.

The designer of the Carrier humidifier has shown how the above theory applies in a very interesting way to the practical operation of air washers and humidifiers and to humidity control. He points out the fact that the cooling effect of air washers and humidifiers when the water is re-circulated is due solely to evaporation and is always in exact proportion to the wet-bulb depression of the air entering.

In a humidifier which has full saturating efficiency the air is cooled exactly to the wet-bulb temperature, while in the ordinary washers the air is cooled only from 60 to 85 per cent of the wet-bulb depression, according to the intimacy of contact between water and air. The spray water always remains at the wet-bulb temperature, and the wet-bulb temperature of the air remains constant regardless of the degree of saturation so long as no heat is added or substracted.

To cool without the addition of any moisture, the water used in the washer must be somewhat below the dew point of the incoming air. By carrying the temperature still lower and increasing the amount of water the washer may be used as a dehumidifier.

The effect of the washer in reducing humidity is similar to that of the jet condenser. The eliminator plates remove the condensed moisture effectively.

Humidity control is of vital importance and it is clear that humidity may be controlled in several ways, as by use of some hygroscopic substance such as wool, hair or silk or by controlling the absolute humidity or dew point with reference to the room temperature; also by the use of a differential thermostat having two elements, one subjected to wet-bulb temperature and the other to the dry-bulb temperature.

The first method is said to be too unreliable to be of much value in accurate work, while the second method of control can be made exceedingly accurate and is well adapted to regulating where there is a change in absolute humidity in the room to be conditioned.

The essential elements are two rods of hard rubber attached to a frame. These rods are arranged horizontally one above the other and the lower one is covered with a cloth which dips in a reservoir of water. This cloth serves as a wick and keeps the rod continually moist. These two expansible rods operate conjointly through a series of levers upon an air valve.

In order that this instrument may operate to maintain a constant percentage of humidity over a range of temperature it is essential that it should produce no movement of the air valve so long as the humidity is constant. These two rods expand in opposite directions and the dry element is provided with an adjustable leverage so that any desired ratio of action may be secured.

The simplest form of this control is that employed in public buildings for winter use. Here the air is saturated, delivered to the room where a higher temperature is maintained, at the temperature of the air washer, and then by varying either temperature and keeping the other constant any desired percentage of humidity may be obtained.

If there is maintained a saturated temperature of 50 degrees at the apparatus and 70 degrees in the room, there will be a relative humidity of 50 per cent; if the dew point at the apparatus is lowered to 40 degrees, still holding the room temperature at 70 degrees, there will be 34 per cent of the humidity in the room as the result. With a dew point at the apparatus of 61 degrees maintaining one room at 70 degrees, another at 75 degrees, and a third at 80 degrees, there would be 75, 64 and 55 per cent of humidity in these rooms respectively.

There was placed in operation an apparatus of this nature in the Central District Printing and Telegraph Company's building at Pittsburg, the air being tempered by direct contact with a heated water spray. The temperature of the spray is so controlled by means of a thermostat as to maintain a constant air temperature past the eliminator plates. The temperature of saturation is ordinarily maintained at 40 degrees. The air is then drawn through the fan and passed through the tempering coils, whence it is forced into the building. This method of fixed dew point regulation is only adaptable for winter use and is employed chiefly in public buildings.

It is impossible to maintain a uniform temperature throughout the summer in textile mills and therefore here it becomes necessary to vary the temperature of the dew point. This fact is taken advantage of in the control of humidity by means of the differential thermostat. This maintains a constant difference between the dew point and the temperature of the room and thereby regulates the humidity regardless of the room temperature.

This thermostat is placed at the apparatus directly back of the eliminator plates and is subjected to the current of saturated air.

Air conditioning must sooner or later be generally adopted in coal mining. The numerous and disastrous explosions that have occurred during the past winter are sufficient evidence that further precautions should be taken. To say that three-fourths of these could have been prevented by proper conditioning of the air supply in the mine is no exaggeration. This, as statistics will confirm, would have saved hundreds of lives and millions of dollars. A large part of these mine explosions were caused by dust, which has accumulated owing to the dryness of the mines.

In the mine the temperature remains uniformly between 55 and 60 degrees winter and summer. It is quite noticeable that there are seldom any explosions during the summer months when the absolute humidity is high. Whenever the dew point of the external air is above the temperature of the mine, moisture is deposited on the walls of the mine. However, when the outside dew point is below 55 degrees the air remains unsaturated and the mine becomes dusty.

In extremely cold weather the moisture contents of the air is very low, and the air when heated in the mine to approximately 55 degrees has an exceedingly low per cent of humidity. This causes the walls to dry so rapidly that it is impossible to keep them moist by any of the usual means of spraying. By use of proper air conditioning apparatus in connection with the air supply, summer conditions may be reproduced in the mines without any appearance of fog, or other objectionable features, and the mines may thus be kept in a perfectly safe condition.

Paint as a Protection Against Rust

ACCORDING to a note published in *Cosmos* the German chemists Liebreich and Spitzer have been conducting some experiments with regard to the protection afforded to iron against rusting by a coat of paint. They come to the conclusion, which is somewhat surprising at first sight, that better results are obtained by the application of a single coat than by painting with two or more coats. The explanation which they offer for this somewhat remarkable observation, is that a single coat is more elastic and less liable to scaling off or cracking than a double coat, and thus affords more perfect protection from atmospheric influences.

Mendelism*

Experiments in Hybridization and Its Great Practical Value

By A. D. Darbishire, M.A.

PERHAPS the most interesting, certainly the most sensational, chapter in the history of biology, when it comes to be written, will be that which deals with the discovery of Mendel's papers and with the fruit which that discovery has borne. We are already in possession of all the material for the former topic; and the first instalment of the fruit which has already been harvested augurs well for the quality of what is to come.

In 1865, a man absolutely unknown to the biological world, Gregor Johann Mendel, read before a meeting of the Natural History Society of Brunn a paper on his experiments with peas, entitled "Experiments with Plant Hybrids." To-day no name is better known to biologists than that of Mendel. And yet, when he died in 1884, he was as obscure as when he read his famous paper. Indeed it was not until sixteen years after his death that Mendel suddenly burst from obscurity into fame.

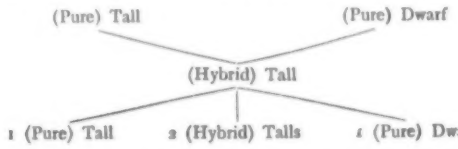
In 1900 Mendel's experiments with peas were repeated, and his results confirmed, independently by De Vries in Amsterdam, Correns in Leipzig, and Tschermak in Vienna.

We must now make it our business to become familiar with the facts which Mendel discovered, and with the interpretation which he put upon them. Mendel found that varieties of the culinary pea, *Pisum sativum*, could be classified according to a number of constant, true-breeding characteristics, such as the form of the plant, whether normal, (i.e. tall) or dwarf; or such as the color of the cotyledons of the seeds, whether yellow or green; and so forth.

Mendel crossed a Tall with a Dwarf. The resulting hybrid was invariably a Tall. Tallness, therefore, he called the *dominant* character and dwarfness the *recessive*.

These hybrids were allowed to self-fertilize (the normal process in *Pisum*), and seeds gathered from them gave, when grown, 1064 plants, of which 787 were tall and 277 dwarf; that is to say, the hybrid Talls produced Talls and Dwarfs in the proportion of 2.84 to 1, or roughly 3 to 1.

The seeds of these plants were sown, and it was found that all the Dwarfs bred true, while of every three Talls, one produced only Talls, the other two giving rise to Talls and Dwarfs in the proportion 3 to 1. The foregoing account may be summarised in the following diagram:



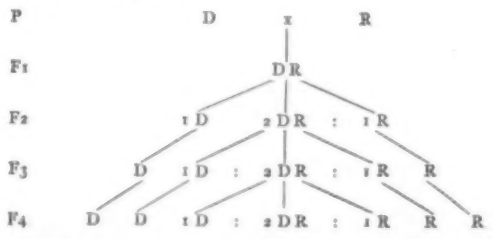
Let us now look at the three kinds of Peas which compose the generation in which Pure Talls, Hybrid Talls, and Pure Dwarfs appear in the proportion 1:2:1. We already know that all the Dwarfs breed true, that a third of the Talls breed true, while the rest of the Talls produce Talls and Dwarfs in the proportion 3 to 1. This proportion—3 to 1—is made up in the same way as the same proportion in the preceding generation, namely, 1 Pure Tall; 2 Hybrid Talls; and 1 Pure Dwarf. All these Dwarfs breed true; all the Pure Talls breed true; and the Hybrid Talls produce Talls and Dwarfs in the proportion 3 to 1. And so on.

There are two sets of symbols which are very convenient in describing these phonomena.

The first set describes the different kinds of individuals; the second the generations. D denotes the dominant form (in the case we have been discussing, the Tall), R the recessive (the Dwarf), and D R the hybrid.

P denotes the parental generation; F1, the result of crossing the two parent forms, in our case, the Hybrid Tall; F2 denotes the next generation, i.e. that in which the dwarfs reappear in the proportion 25 per cent.

We may now summarize the Mendelian phenomenon in the following diagram:



What is the cause of this beautifully regular and definite phenomenon? Mendel answered the question in this ingenious way. He believed that the germ-cell of the hybrid pea did not represent a mixture of tallness and dwarfness, but that a germ-cell represented *either* a tall *or* a dwarf, and, moreover, that half of the germ cells represented tall and half of them dwarfs. Let us see what is the result of the union, say, a hundred male germ-cells, or pollen cells, with a hundred female germ-cells, or egg-cells. Before we proceed, let us make certain of two points which are essential to the argument. Mendel believed that a pure-breeding tall pea contained only tall-representing germ-cells, in fact, that the reason that it bred true was that it did contain them; and that the dwarf contained only dwarf-representing germ-cells. Mendel had also found that the result of a union between a "tall" germ-cell and a "dwarf" one was a hybrid which bore the tall character. Now let us return to our argument.

Fifty of the hundred pollen-cells would be "tall," and fifty "dwarf." Let us consider the "talls" first. As half of the eggs-cells are "tall" and half "dwarf," the "tall" pollen-cell has an equal chance of meeting a "tall" and a "dwarf" egg-cell. So that twenty-five of the "tall" pollen-cells would meet "tall" egg-cells, and twenty-five would meet "dwarf" ones; and the resulting unions would be (writing T for Tall, and D for Dwarf):

25 T T
25 T D

Similarly twenty-five of the fifty "dwarf" egg-cells would meet "talls" and twenty-five "dwarfs," or briefly:

25 D T
25 D D

The total result therefore is:

25 T T
25 T D
25 D T
25 D D

Now we already know that the result of the union of a "tall" with a "dwarf" germ-cell is a hybrid which is tall, and Mendel found that it made no difference whether the tall character was carried by the male parent and the dwarf by the female, or *vice versa*. So that the above result can be written:

25 T T (Pure Talls)
50 T D (or D T) (Hybrid Talls)
25 D D (Pure Dwarf)

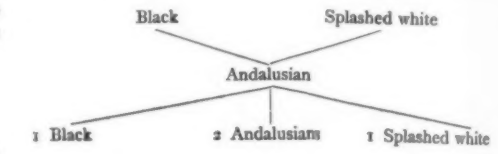
The result of the random union of two sets of germ-cells each set consisting of 50 per cent. of germ-cells bearing the Recessive and of 50 per cent. bearing the Dominant character, can be admirably illustrated by drawing one counter at random from a hat containing fifty Red and fifty White counters, and another from another hat with similar contents, and by placing the three kinds of pairs in three separate rows on the table, according to whether they are R W, R R, or W W. The larger the number of trials you make the closer will the approximation to the proportion of 25 R R, 50 R W, 25 W W be. Counters are worse than marbles for illustrating this, by reason of the difficulty of thoroughly shuffling them. But they are better than them, because the phenomenon of dominance and the proportion 3 : 1 can be illustrated with them, the former by merely making it a rule to put the red counter on the top of the white when a red and a white are drawn together, the latter by superposing the upper counter in every pair so carefully that the lower one is invisible. If this is done effectively there will be seen, at any rate from a slight distance, to be 75 per cent red counters and 25 per cent white. But if you jog the table the difference between the previously apparently identical reds will be revealed. It is also very easy to illustrate subsequent results with the counters. The result of mating the hybrids in F2 can be illustrated in exactly the same way as that of mating the F1 hybrids. And it is readily seen that it is no more possible to get anything but Dwarfs from Dwarfs in F2 than it is possible to get anything but pairs of white counters by drawing from two hats each containing nothing but white ones, and that it is no more possible to get anything but Talls from those Talls, i.e. the pure ones, which resulted from the union of like gametes than to get anything but pairs of reds from drawings from two hats containing only reds.

The animal or plant resulting from the union of two germ cells or gametes—and all animals and plants which reproduce sexually result from such a union—is called a *zygote;* that resulting from the union of like gametes or germ-cells is called a *homozygote;* that from the union of unlike gametes a *heterozygote*.

The heterozygote in the case which we have been considering as an example was only distinguishable from the dominant homozygote by the fact that when allowed to self-fertilize it produced Dwarfs as well as Talls. But sometimes the result of crossing the two pure strains is different from either of them, that is to say, the heterozygote has a character peculiar to itself. This makes it possible to distinguish between the heterozygotes and the dominant homozygotes in F2 otherwise than by breeding from them.

The phenomenon may be illustrated by the famous case of the Andalusian fowl. If you buy a pair of these birds from the very best source you will find that they will not breed true, but that they will produce besides the Andalusians blacks and splashed whites, and that on the average the three forms will be produced in the proportion 1 black, 2 Andalusians, 1 splashed white. If you were not acquainted with Mendelian phenomena, but were guided by the principles of heredity which were universally held in pre-Mendelian days (and still held by those who are not Mendelians), you would sell the blacks and whites for eating and breed from the Andalusians, in the belief that, as they at least, to your own personal knowledge, had an Andalusian father and mother, they would be more likely to breed true than a pair of Andalusians of unknown and, as you would expect from the result of mating them, of mixed parentage. Your anticipation would not be fulfilled. Your Andalusians would again produce blacks, Andalusians, and splashed whites in the proportion 1:2:1. But if you were acquainted with Mendelian phenomena you would immediately suspect that the Andalusians was a heterozygote form, and that the two homozygote forms which by their union gave rise to it were the blacks and the splashed whites. This is indeed the case. Mate the black and the splashed white, and you get nothing but Andalusians. The obvious plan, therefore, instead of selling the blacks and whites to the poulterer and keeping the Andalusians to breed from, and then only getting 50 per cent of what you want, is to sell the Andalusians to fanciers, keep the blacks and whites, and get 100 per cent of Andalusians by crossing them, making occasional matings of Andalusians to keep up the supply of blacks and whites.

This case is summarized in the following diagram:



Let us now return to the Peas. We have referred in detail to only one pair of characters, namely, Tall and Dwarf. Mendel dealt with six other pairs of characters, namely:

1. The shape of the ripe seeds, which were either round or wrinkled.
2. The color of the ripe cotyledons in the seed, which were either yellow or green.
3. The color of the seed coat, which was either white or gray (with or without purple spots).
4. The texture of the ripe pods, which was either hard and inflated or soft and constricted between the seeds.
5. The color of the unripe pods, which was either green or yellow.
6. The arrangement of the flowers on the stem. The flowers either came off normally at the nodes along the stem, or they were situate in a bunch at the top of the stem; this latter is the so-called Mummy habit.

The two members of each of these pairs of character stand to one another in the relation of dominant and recessive. In the above list the dominant member of each pair is written first. The two characters which form such a pair are called *allelomorphs;* and green is said to be allelomorphic to—i.e., forms the other member of a pair with—yellow. Similarly yellow is allelomorphic to green.

We have so far, in considering the results of crossing an animal or a plant, paid attention only to a single pair of allelomorphs, tall and dwarf, black and splashed white. We must now ask ourselves, What is the relation between character belonging to different allelomorphic pairs? And the answer broadly speaking, is that in the case of some characters there is no relation, while in the case of others there is; or, to amplify the answer, in the case of some characters the members of distinct allelomorphic pairs exercise a very definite effect on one another, while in the case of others they are entirely independent of one another. We will deal with the latter case first, because it is simpler.

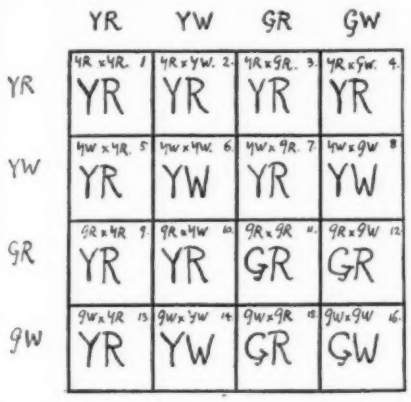
What the result of mating a green round with a yellow wrinkled pea will be, can be answered by reference to the table above, in which the dominant member of a pair is written first. The result will be a yellow round one. What the result of allowing these to self-fertilize will be can be predicted from the result of making drawings of two counters from each of two hats, which contain equal numbers of green and yellow, red and white counters.

The number and nature of the possible combinations

*Abstracted from *Science Progress*.

is given by the number and contents of the squares in the table.

Y and G stand both for yellow and green counters and "yellow" and "green" germ-cells; R and W stand both for red and white counters and "round" and "wrinkled" germ-cells. The four pairs of letters along the top of the table represent the four kinds of male gametes; the pairs along the side the four kinds of female ones; the squares represent zygotes. Let us consider the results of their union, beginning at the top left-hand square. (In the following account Y is to be read as yellow, G as green, R as round, and W as wrinkled.) Here we have to do with union between two Y R gametes. The result is a pure Y R zygote. In the square to the right of it, it is a case of a union between a Y R egg-cell and a Y W pollen-cell; the result is a Y R zygote, which is a homozygote as regards color and a heterozygote as regards shape. In the next square to the right a Y R gamete meets a G R



gamete; the result is again a Y R zygote, which differs from the last in that it is homozygote as regards shape and heterozygote as regards color. In the last square on the top line a Y R gamete meets a G W one; the result is a Y R which differs from any of the preceding ones by being heterozygotes both as regards color and shape. And so on throughout the table. The nature of the sixteen possible kinds of unions of gametes is written in small letters in the sixteen squares of the table. The characters of the resulting zygotes are written in large letters. When this explanation is being illustrated with counters, the nature of the zygote in each case is given by making it a rule always to put a yellow on the top of a green counter and a red on the top of a white.

The result therefore of allowing our Y R hybrid (produced by Y W and G R) to self-fertilize should be:

9 Yellow round (squares 1, 2, 3, 4, 5, 7, 9, 10, and 13).
3 Yellow wrinkled (squares 6, 8, and 14).
3 Green round (squares 11, 12, and 15).
1 Green wrinkled (square 16).

Or, briefly, 9 Y R, 3 Y W, 3 G R, 1 G W in every sixteen peas.

Of the 9 Y R, only 1 (square 1) is homozygous in both respects, and should produce only Y Rs. Two Y Rs are homozygous in color only, but heterozygous in shape (viz., squares 2 and 5); they should produce only yellow, but both "Rounds" and "Wrinkleds." Two Y Rs are homozygous in shape, but heterozygous in color (viz., squares 3 and 9); they should produce only rounds, but both "Yellows" and "Greens." The remaining 4 (squares 4, 7, 10, and 13) are heterozygous both in color and in shape, and should produce all 4 kinds—Y R, Y W, G R, and G W.

On the 3 Y W, 1 (square 6) is homozygous in both shape and color, while the remaining 2 (squares 8 and 14) are homozygous in shape only. Similarly with the 3 G Rs, that in square 11 is homozygous in both respects, the other 2 (squares 12 and 16) being homozygous in color only. It will, of course, be noted that the character in respect of which all the 3 Y Ws and all the 3 G Rs are homozygous is a recessive one, namely, wrinkledness in Y W and greenness in G R.

There is only 1 G W zygote which, since both its characters are recessive, is therefore homozygous in both respects.

A very close approximation to the result 9 Y R, 3 Y W, 3 G R, 1 G W has been obtained in experiments by Mendel, Bateson, Hurst, and myself. And the various types of Y R, Y W, and G R have also been recognized.

Another point of view from which the proportion 9 : 3 : 3 : 1 may be regarded is from that of the zygotes solely. If we have a generation which displays the two characters of one pair Y and G in the proportion 3 Y to 1 G in every 4, and the two characters of another pair R and W in the proportion 3 R to 1 W in every 4, and if we further suppose that the two pairs are independent of one another, we should expect that in every 16 (= 4 × 4) 9 (= 3 × 3) would be Y and R, 3 (= 3 × 1) Y and W, 3 (= 3 × 1) G and R, and 1 (= 1 × 1) G and W. And we find that this is so, which shows that the two pairs are independent of one another.

Having become familiar with the signification of the 9 : 3 : 3 : 1 proportion, let us proceed to the discussion of other results which can only be interpreted in the light of it. We need not leave the Pea for illustration. If we ask a corn-dealer for a pennyworth of Maple or Partridge Peas, he will give us a kind of pea the seed-coat of which at first glance appears a uniform brown, but on closer inspection is seen to have a ground color of a pale brown, on which is a very beautiful mottling, consisting of anastomosing tracts of a rich brown color. This type of coloration is called mapling. Another type of coloration is that which is often seen on (though it is not necessarily associated with) the kind of pea which is much grown and eaten on the Continent, and known as the Sugar Pea. In this type of coloration there are minute spots (discernible by the naked eye) of slightly varying sizes and of a rich purple color on a greenish gray background. The former type will be referred to as "maple" and the latter as "purple spot."

When a pea with a maple seed-coat is crossed with one with a purple spotted coat, the result is a pea on whose seed-coat both mapling and purple spots exist. This suggests that maple and purple-spot are not allelomorphic to one another, but belong to separate pairs which are supposed to be maple (M) and not-maple (nM), and purple spot (P) and not-purple spot (nP). This sounds very much like a logical exercise, a matter of words and not of things. But the reality of it is shown by breeding from the hybrids; for by doing this we actually get peas, which we can touch and see, which exhibit neither mapling nor purple spotting. We get, in fact, the following four types of peas in the proportions given by the numbers which precede them:

9 M P, 3 M, 3 P, 1 gray.

If we write this in a form analogous to—

9 Y R, 3 Y W, 3 G R, G W—

we should have:

9 M P, 3 M nP, 3 P nM, 1 nP nM.

The nP nM is gray because all these colors are on a back-ground of pale gray. This proportion shows that we are dealing with two independent pairs of characters, viz.:

1. Maple and not-maple.
2. Purple spot and not-purple spot.

Now we come to those cases in which one of the characters of a pair of allelomorphs is not independent of a character in another pair.

We will cross a pea with a pale gray seed-coat, such as that which formed the background for the purple and the maple (many field peas exhibit no more than this gray color), with a pea with no color at all in its seed-coat, as is the case in a great number of the peas grown for the table. The result is a gray-seeded pea *on which there are purple spots*, which existed in neither parent. Heretofore this would have been labeled as an example of reversion and the matter would have been regarded as settled, or at any rate done with. But to call a thing reversion does not make one any wiser about it. Mendelism has provided a reasonable explanation of reversion in this case. Let us see how. The result of breeding from these gray-coated purple-spotted hybrids provided the clue. There were produced 9 gray with purple spots, 3 gray, and 4 white.

What does this mean? The 9 : 3 : 3 : 1 proportion suggests an explanation. It is supposed here, as in the case of the cross between the maple and the purple spot, we are dealing with two pairs of allelomorphs, namely, (1) gray (G), and not-gray (nG), and (2) purple spot (P) and not-purple spot (nP). The gray pea exhibits the dominant gray character (G) of that pair. The white pea possesses—and here we come to the case of the interdependence of characters in separate pairs—the dominant purple spotting (P) of that pair; *but the purple spotting is not exhibited because one of its properties is that it cannot be manifested unless associated with the gray coat.* Bearing this theory in mind, let us write the 9 : 3 : 3 : 1 scheme for the two pair of allelomorphs G and nG, P and nP. It will be:

9 G P, 3 G nP, 3 P nG, 1 nP nG.

But we see that in the 3 P nG the purple spot is there, but the gray coat is not. Therefore *ex hypothesi* it will not be manifested and these three seeds will appear white, which gives the proportion 9 gray with purple spots, 3 gray and 4 white.

The possession by the hybrid of a character which neither of its parents possesses is accounted for by supposing that that character (in this case purple spotting) depends for its manifestation on two factors (in this case P and G), one of which exists in one parent and the other in the other. This Mendelian hypothesis therefore enables us to account for the reversion and for the otherwise meaningless proportion 9 : 3 : 4; or perhaps we should not say more than that the facts are consistent with the truth of this theory.

Mendelian inheritance is by no means confined to color characters, as we shall shortly see. Perhaps one of the most striking instances of this is that studied by von Guaita, Weldon, and myself, the waltzing habit in mice. The waltzing habit characterizes a race of mice known as Japanese waltzing mice, which have pink eyes and small patches of fawn on the shoulders and rump. A waltzing mouse does not always waltz, but can always be distinguished immediately from a normal mouse. The waltzing itself consists in merely spinning round and round very swiftly in one spot on all-fours. It is not in the least like waltzing. It is simply running round in a circle sometimes at a very great pace for several minutes at a time, so that all that you can see is a sort of nebulous ring of mouse. They do not always go round in the same direction, but sometimes in a right-handed direction, sometimes in a left. But when it is not waltzing, a waltzing mouse is immediately recognizable by the appearance of complete lack of control over the movements of its head, which is every now and again thrown back into an apparently very uncomfortable and useless attitude. A waltzing mouse also has the habit of running or rather shuffling backward, waving his head vigorously from side to side the while.

Probably the waltzing feature arose as a sport which was carefully preserved and bred from. Waltzing is, in fact, a very good example of the kind of character that can arise in a tame breed, and be preserved because it tickles the fancy of man. Nature does not tolerate curiosities of this kind for a moment, and promptly eliminates them. The abnormality is due, not, as was originally believed, to the absence or atrophy of one of the semicircular canals, which have been demonstrated to be all there, but to a deficiency in their nerve supply. The waltzing is a constant character of the race; the children of waltzing mice mated together being all waltzers.

When such a waltzing mouse is mated with a normal mouse—with an ordinary white mouse, for example—the hybrid obtained is always *normal*, like the white mouse. Waltzing, therefore, is recessive, in the Mendelian sense, to normality of progression. In F2 we should expect the waltzing to reappear in the proportion of 25 per cent of the whole fraternity. Reappear it certainly does, but not quite in the proportion expected. The number of waltzers, indeed, falls below 20 per cent, in the many hundreds of F2 mice which I have raised. I do not think that this deficiency is due to any complication of the process of segregation in the germ-cells, but believe it is merely due to the greater mortality which almost certainly takes place among waltzing individuals than among normal ones between the time when they are born and the age—from ten days to two weeks—when the characters of the mice are first registered. Waltzers are much more delicate than normal mice; and it is likely that this delicacy is more fatal in youth (perhaps even before birth) than in middle age.

The mice afford an excellent example of reversion. The Japanese waltzing mouse is almost an albino, and would be were it not for the patches of fawn-colored fur on the shoulders and haunches. It has pink eyes. It was crossed with an albino mouse. The result, where the albino used was a pure-bred one, was a mouse hardly distinguishable at first sight from the common house mouse. A closer inspection reveals the lighter color of the belly. Their eyes are jet black. And this is the most remarkable feature of the cross—the production of a black-eyed form from two parent forms both of which had pink eyes. These hybrids are not merely wild in their coloration, but are always noticeably healthier, stronger, and wilder than their albino parent, and infinitely more so than their waltzing parent. As already stated, they never waltz. When they are mated together they produce a generation which is composed of the three color catagories we have just mentioned in the proportions indicated by the percentages prefixed to them, viz., 25 per cent pink eye and colored coat (that of the Japanese waltzer), 50 per cent dark eye and colored coat (that of the hybrid), and 25 per cent pink eye and colorless coat (i. e. complete absence of pigment or albinism). The distribution of waltzing over these various color categories is interesting. It is distributed, as it were, at random, that is to say, the waltzing character is not necessarily associated with that color category with which it was associated in the pure waltzer, but may be associated with any of the three color categories. So that we get in F2, besides waltzers colored like their pure grandparents, waltzers with the black eyes and the gray coat of the house mouse, and albino waltzers. It may be noted in passing that these albino waltzers correspond to the green wrinkled peas we have already discussed, that is to say, they represent the association in F2 of the recessive character of one parent with the recessive character of the other parent in one individual, which, since both characters it bears are recessive, may be counted on to breed true. It does.

Another illustration of a character other than color is that which has been studied by Mr. R. H. Biffen. One of the most disastrous pestilences which affect the wheat is the fungoid pest known as Yellow Rust (*Puccinia glumarum*). Some varieties of wheat are more susceptible to it than others; for example, the variety Michigan Bronze is hardly ever free from it. Another variety grown by Mr. Biffen may be regarded as practically immune, for, although it was grown for four years in close proximity to the most rust-stricken varieties, it was not affected by the disease. This immune variety was crossed with Michigan Bronze. The hybrids were all so badly affected by the disease that one could not

find an area an eighth of an inch square unattacked by the rust. No difference in respect of their susceptibility to the disease could be discerned between the hybrid and Michigan Bronze. But the hybrid did differ from it by the fact that whereas the susceptible parent hardly set a grain, the hybrid gave a moderate crop.

"Every available grain was sown in plots alongside the parent varieties, part on land which had been exhausted on a previous crop of wheat, and part on land which had carried a crop of clover the previous season and consequently was in high condition. The difference in cultivation, however, made no difference in the results of the experiment. The rust was late in appearing that season, but again every plant of the susceptible parent was stricken, and all of the immune type escaped entirely. The hybrid plots were badly attacked, and when the epidemic seemed to be well advanced, the plants were sorted into two groups, namely, those attacked, and those showing no signs of the disease even on the withering basal leaves. On some plots the diseased plants were cut out, leaving those free from infection for a subsequent examination. A few individuals, which had escaped the attack at the early stage, became infected later, and these were then added to the total of susceptible plants. The statistics showed that 1,609 diseased plants were present and 523 immune, or a ratio of 3.07:1. There cannot, I believe, be any question that these latter were really immune, for they were surrounded by plants covered in rust, whose leaves were continually rubbing against them. Further, if a variety is susceptible, no plant of it under field conditions ever appears to escape."

Mr. Biffen concludes with the following remark: "Of the problems this opens up to the pathologist, nothing need be said here: for the present we are concerned with plant improvement, and it need only be noted that, according to the report of the International Phytological Bureau in 1890, the attacks of rust cost Germany some $100,000,000. Such figures give one some idea of the stakes the plant-breeder can now play for, and, thanks to the work of Mendel, with the reasonable certainty of winning."

But it is not merely by the discovery of facts of this kind that Mendelism is of service to the breeder of animals and plants.

Mendel and his followers have already put into the hands of breeders general principles of the greatest value. For example, those whose business is to breed cattle or carnations, or whose hobby is to breed fancy mice or sweet peas, and strive to improve their strains by crossing, are likely to be disappointed if they expect anything new in their first crosses. What could be more discouraging than to obtain a house mouse by crossing the delicate little waltzing mouse with the albino? And yet I have raised an entirely new color, lilac, as it is called, by mating these hybrids together. Similarly in sweet peas the production of the original wild type of that flower by crossing two of the most beautiful modern strains would not tempt one to repeat the experiment. Mendelian principles drive home the lesson that we must expect nothing in the way of novelty from the first generation, and that it is on the next one that we must concentrate our attention.

Another extremely valuable instrument which Mendel has put into the hand of the breeder is the power of effecting the combination in one strain of desirable characters existing in separate strains, with great swiftness and precision. If the two characters we wish to combine are recessive ones, our task is an easy one, for we can effect their association in 1 individual in every 16 in the F2 generation. If, however, it is a dominant one, we will have to wait till the following generation in order to determine which of the individuals bearing the dominant character are heterozygotes and which homozygotes.

Meat Saved Pays Cost of Electric Cooking*

THAT in a 9-pound leg of mutton as much as 1½ pounds of meat may be saved by cooking in an electric oven, compared with cooking the same joint by gas or coal, was pointed out by Mr. J. D. A. Cross, Chicago, in a paper read by him before the Wisconsin Electrical Association, January 19th.

A number of careful and independent experiments in England, said Mr. Cross, have shown that there is a shrinkage of from 25 to 35 per cent in the weight of meat cooked by coal or gas, whereas the same kind of food cooked to the same degree by electricity loses only 10 or 15 per cent of its original weight. Thus it is conceivable that even if coal or gas cost nothing it would be cheaper to use an electric oven and pay a comparatively high rate per kilowatt-hour for electricity, for the loss due to electric cooking is so slight compared with that sustained when gas and coal ovens are employed that a very considerable saving is effected on the butcher's bill.

Table I, prepared by Mr. K. B. Matthews, an English electric heating engineer, shows a compilation of a number of experiments made with various kinds of heat for cooking.

* By courtesy of the *Electrical World*.

TABLE I.—RESULTS FROM ELECTRICAL COOKING.

Joint.	Weight before cooking.		Weight after cooking.		Type of oven.	Loss of Weight		Loss per cent.
	Lb.	Oz.	Lb.	Oz.		Lb.	Oz.	
Ribs of beef	5	7	3	12	Coal	1	11	31.0
Leg of mutton	8	8	5	13	Coal	2	11	31.7
Shoulder of mutton	6	13	5	1	Coal	1	12	25.7
Leg of mutton	8	4	6	0	Gas	2	4	28.1
Leg of mutton	8	0	7	12	Elect'y	1	4	13.1
Shoulder of mutton	4	12	4	2	Elect'y	0	10	13.1
Ribs of beef	9	1	7	6	Elect'y	1	11	18.6
Leg of mutton	9	1	7	10	Elect'y	1	7	15.8
Shoulder of mutton	5	10	5	0	Elect'y	0	10	11.1

Tables II and III show the relative quantities of meat to be purchased in order to serve a given amount when the cooking is done with electricity, coal and gas, respectively.

TABLE II.—COOKING BEEF BY ELECTRICITY, COAL AND GAS, RESPECTIVELY.

Weight of Cooked Joint.	Weight to be ordered from butchers when cooking is to be done by						Saving of meat and money when electricity is used instead of					
	Electricity.		Coal.		Gas.		Coal.			Gas.		
Lb.	Lb.	Oz.	Lb.	Oz.	Lb.	Oz.	Lb.	Oz.	Value.	Lb.	Oz.	Value.
4	4	8	5	11	5	14	1	3	$0.28	1	6	$0.32
5	5	11	7	3	7	6	1	8	0.36	1	11	0.40
6	6	13	8	9	8	13	1	12	0.42	2	0	0.46
7	7	9	10	0	10	5	2	1	0.50	2	6	0.56
8	9	2	11	7	11	13	2	5	0.56	2	11	0.64
9	10	4	12	4	13	4	2	10	0.62	3	0	0.72
10	11	6	14	5	14	11	2	15	0.70	3	5	0.80
11	12	8	15	11	16	3	3	3	0.76	3	11	0.88
12	13	10	17	2	17	11	3	8	0.84	4	1	0.98

TABLE III.—COOKING MUTTON BY ELECTRICITY, COAL AND GAS, RESPECTIVELY.

Weight of Cooked Joint.	Weight to be ordered from butchers when cooking is to be done by						Saving of meat and money when electricity is used instead of					
	Electricity.		Coal.		Gas.		Coal.			Gas.		
Lb.	Lb.	Oz.	Lb.	Oz.	Lb.	Oz.	Lb.	Oz.	Value.	Lb.	Oz.	Value.
4	4	8	5	7	5	8	0	15	$0.20	1	0	$0.20
5	5	11	6	13	6	15	1	2	0.24	1	4	0.25
6	6	13	8	2	3	5	1	5	0.26	1	8	0.30
7	7	15	9	7	9	11	1	8	0.30	1	12	0.36
8	9	2	10	13	11	2	1	11	0.34	2	0	0.40
9	10	4	12	2	12	8	1	14	0.38	2	4	0.46
10	11	6	13	8	13	15	2	2	0.42	2	9	0.52
11	12	8	14	14	15	5	2	6	0.48	2	13	0.56
12	13	10	15	4	16	11	2	10	0.54	3	1	0.62

Novel Scent Bottle

FOR the purpose of disseminating perfumes continuously without risk of spilling the liquid, a French inventor has devised a small glass tube, having at each end an orifice, to which is fitted a short tube of almost capillary bore, open at both ends and extending nearly to the middle of the larger tube. It will be evident from an examination of Fig. 2 that if a small quantity of liquid perfume is introduced into the tube by aspiration no leakage can occur in any position of the tube, while the scented vapor can always escape freely through both capillary tubes. One of these novel scent bottles, carried in the pocket and heated by the warmth of the body, diffuses a strong fragrance and becomes exhausted in a few days. The device may also be employed, alone or in combination with a mouthpiece, such as the imitation cigar shown in Fig. 1, for the inhalation of turpentine, guiacol, and other volatile medicaments.

Fig. 1.—Perfume tube inclosed in imitation cigar.

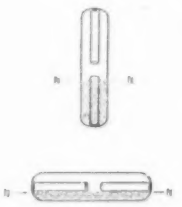


Fig. 2.—Sections of tube, with liquid indicated by shading

Stopping for Sweating Casks.—Vaseline, 1 part; paraffine, 1 part, are melted together and as much dry pipe clay mixed in as will produce a stiff paste, which is made homogeneous by kneading.

The Influence of Ozone on Ventilation

THE article by Messrs. Hill and Flack on this subject, which appeared in last week's issue of the SUPPLEMENT, was the report of a paper read by the authors before the Society of Arts, and originally published in the Journal of that Society.

Through a regrettable oversight due credit to this source was not given at the time, and we hasten to rectify the omission.

Science Notes

Rapid Drying for Negatives.—We read in *Cosmos* that Messrs. Lumiere & Seyewetz have worked out a new method for quickly drying negatives. The plate to be dried is plunged into a 90 per cent solution of potassium carbonate and is allowed to stay there for four or five minutes, after which it is dried with blotting paper and rubbed with a clean rag, to remove the adherent sodium carbonate solution. It is said that this method is much more satisfactory than drying with alcohol.

Fish Meal.—Fish is consumed not solely as food for the human population. It can also be fed in proper doses to cattle. Experiments in this direction have been made in Norway and Great Britain. It is found that pigs take this food with considerable relish, and also cows and calves consume it. The following, according to the *Revue Scientifique*, is a method of preparing the product. In Norway the cod and herring are principally used. The codfish are dried first in the air, then in the oven, and finally the mass is ground, the resulting product containing, on an average 50 to 60 per cent albuminoids, 1 to 2 per cent fat and 24 to 28 per cent of calcium phosphate. The herrings are made into meal by first boiling them and then passing them through a press. The product obtained from fresh fish contains 60 to 70 per cent of albuminoids, 10 to 12 per cent of fat and 8 to 18 per cent of calcium phosphate. In England and Scotland fish meal is obtained from waste from all sorts of fish, which is first treated with steam and then dried and ground.

Metabolism in Mental Work.—Although it has long been realized in a general way that mental work must be accompanied by an increased consumption of living tissue, hitherto it has been difficult or impossible to demonstrate definitely that such an increase actually does take place during mental activity. Dr. Lehmann, writing in *Die Umschau* reports on some experiments which he has carried out and which seem to definitely establish this point. He draws attention to the fact that the failure which has attended efforts hitherto to investigate this matter must be ascribed to the fact that in order to obtain satisfactory results the person under experiment must be absolutely inactive physically; otherwise, the influence of mental work is completely masked by the effects of physical exertion. He therefore arranges his experiments in such a manner that the subject is absolutely motionless during the period of observation. He is then given some simple mental task, such as a series of additions of multiplications, to do, and the amount of carbon dioxide eliminated per second is measured. The results obtained were entirely concordant among themselves and showed a distinct increase in the elimination of carbon dioxide. Furthermore, as one would only expect, it was found that during the earlier stages of the work, for a given amount of work, the rate of production of carbon dioxide is less than during the later stages, showing that the effort which has to be made to do a certain amount of work increases as a person becomes fatigued. It is also found that for a given type of work and for a given person, under specified conditions, the increase in the production of carbon dioxide is approximately constant, though it differs from person to person.

WE wish to call attention to the fact that we are in a position to render competent services in every branch of patent or trade-mark work. Our staff is composed of mechanical, electrical and chemical experts, thoroughly trained to prepare and prosecute all patent applications, irrespective of the complex nature of the subject matter involved, or of the specialized, technical, or scientific knowledge required therefor.

We are prepared to render opinions as to validity or infringement of patents, or with regard to conflicts arising in trade-mark and unfair competition matters.

We also have associates throughout the world, who assist in the prosecution of patent and trade-mark applications filed in all countries foreign to the United States.

MUNN & CO.,
Patent Attorneys,
363 Broadway,
New York, N. Y.

Branch Office:
625 F Street, N. W.,
Washington, D. C.

TABLE OF CONTENTS

PAGE

Iron and Steel Metallurgy in Brief 354
International Trade-mark Law.—By Dr. Martin Wassermann 354
The Denier System of Silk Measure.—By James Chittick 355
Autochrome Exposures, by Flashlight 355
Smokeless Chimneyless Steam Plants.—5 illustrations 356
Cooling Ammunition Quarters of French Battleships.—By Our Paris Correspondent.—1 illustration 357
The Houdaille Emergency Wheel for Automobiles.—1 illustration 357
The Seventieth Anniversary of the Use of Ether in Surgery 357
Motor Flight and Air Sailing or Gliding.—By Carl von Lilienbach 358
Recent Cancer Research.—I.—By W. R. MacDermott, M.B. 359
From the Days of the Romans.—By P. F. Mottelay.—8 illustrations 360
The Synthesis of India Rubber 362
Immunity and Its Mechanism 363
Air Washers and Humidifiers for Public Buildings.—3 illustrations 364
Mendelism.—By A. D. Darbishire, M.A. 366
Meat Saved Pays Cost of Electric Cooking 368
A Novel Scent Bottle.—1 illustration 368
Science Notes 368

Page
354
354
355
355
356
357
357
357
358
359
360
362
363
364
366
368
368
368